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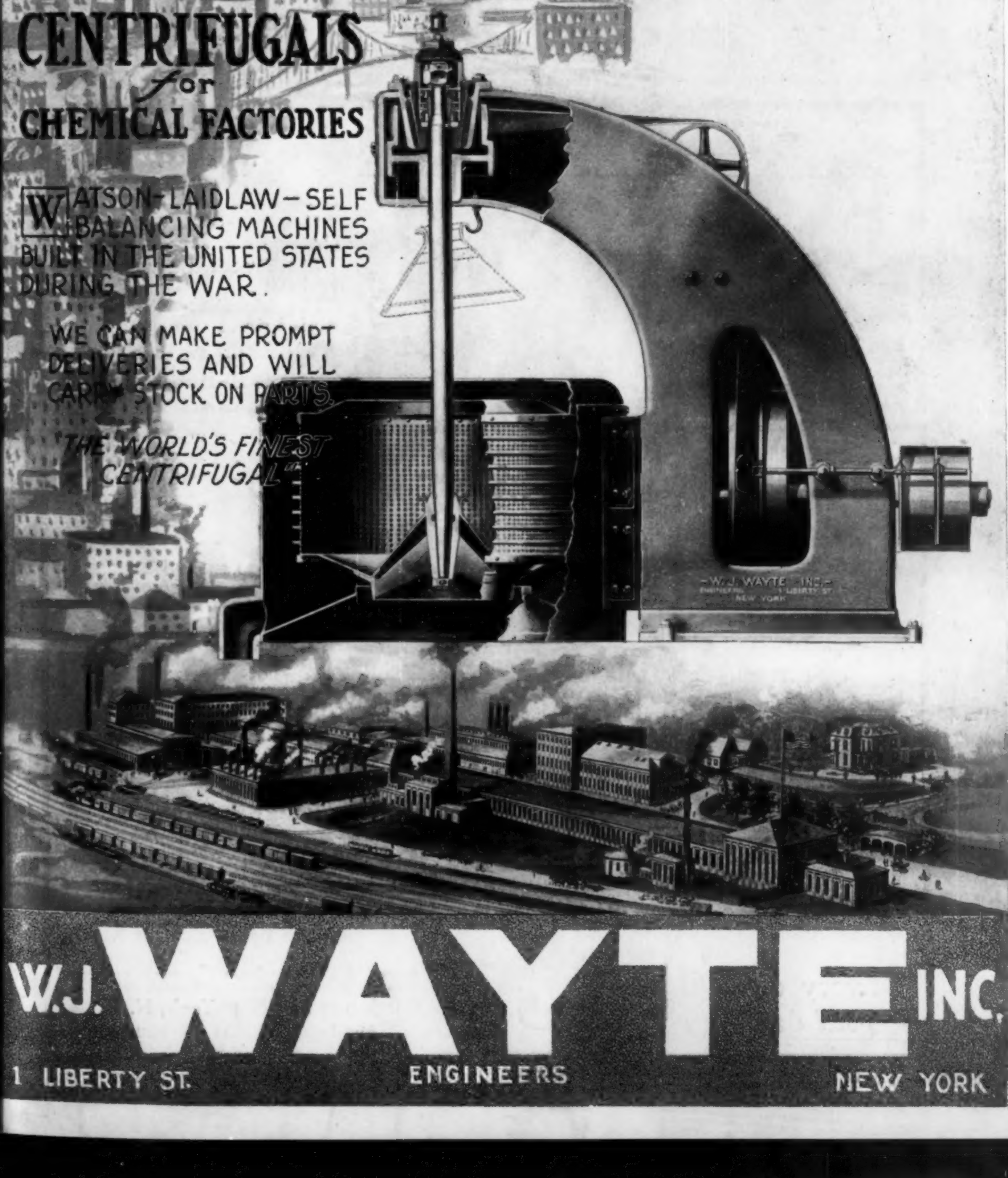
CHEMICAL & METALLURGICAL ENGINEERING



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CHEMICAL & METALLURGICAL ENGINEERING

A *consolidation of* ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

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Volume XX, *Number* 12

Minerals Separation Wins Doubtful Victory

ON JUNE 2 the Supreme Court handed down its decision in the Butte and Superior infringement suit involving Minerals Separation patent 835,120. This is the same patent which was under consideration in the Hyde case, in which the Supreme Court sustained the validity of the patent and defined its elements to be the use of oil in critical proportions amounting to a fraction of one per cent upon the ore, in combination with greater agitation than that theretofore used, and producing a froth different from any previously produced. But that decision did not, it now seems, define the scope of the claims. The opinion in the Butte and Superior case just handed down defines the scope of the claims as to quantity and character of the oils, and places throughout the most insistent emphasis upon the means described in the patent for carrying out the process of the patent. The process is now stated to be one employing any quantity less than one per cent, on the ore, of an oil or oily substance having preferential affinity for metal over gangue, in which air bubbles are introduced into the pulp by agitation.

As to the operations of the Butte and Superior Company the opinion says:

> The evidence shows, and counsel now admit, that prior to the decision by this court in December, 1916, the respondent used, in its ore concentration operations, various oils in quantities less than one-half of one per cent, on the ore, but that from January 9, 1917, to the time of trial, with the exception of two or three weeks, it used oils of a composition which we shall discuss later on, in quantities in excess of one per cent on the ore. In other respects its methods were substantially those of the patent in suit.

It is interesting to note the last sentence in the above quotation. The opinion adds:

> On this showing, the District Court found the patent infringed by the respondent, when it used oil in quantities greater than, as well as when it used it in quantities less than, one per cent on the ore. . . . The Circuit Court of Appeals held the patent infringed only when the respondent used oil in quantities equal to, or less than, one-half of one per cent on the ore, and it therefore reversed both of the holdings of the District Court, but allowed recovery for the period when less than one-half of one per cent of oil on the ore was used.

It will be seen that there were three periods considered as to the use of oil. The use of less than one-half of one per cent up until the time of the decision in the Hyde case; in excess of one per cent after that time, with slight exception of the periods during which the use of oil was over one-half per cent but less than one per cent.

The Circuit Court of Appeals decided that oil in excess of one-half of one per cent did not infringe; it

> derived its authority to limit the claims to one-half of one per cent on the ore from the construction which it

placed upon the following clause of the opinion of this court in the former case, viz.:

"The patent must be confined to the results obtained by the use of oil within the proportions often described in the testimony and in the claims of the patent as 'critical proportions,' 'amounting to a fraction of one per cent on the ore.'"

The reasoning which carried two members of the court to their conclusion was that, as shown by the evidence of the patentees and the argument of their counsel, the amount of oil which is "critical" in the sense of marking the point of transition from the processes of the prior art to the process and discovery of the patent is one-half of one per cent of oil on the ore, and that therefore this court, by using the expression quoted, intended to limit the claims, not to a "fraction of one per cent" but to a "fraction of one-half of one per cent on the ore."

But the Supreme Court reversed the Circuit Court of Appeals, saying:

> The two expressions "critical proportions" and "amounting to a fraction of one per cent on the ore" being used, the former derived from the evidence and the latter from the claims of the patent, obviously, to the extent that they differ—if they differ at all—the language of the claims must rule in determining the rights of the patentees.

Judge BOURQUIN in the District Court had found oil used by the defendant in excess of one per cent an infringement upon the theory that kerosene and fuel oil were of no benefit, when used in a mixture having a quantity of pine oil sufficient in itself to produce the results of the process, and decided that therefore the kerosene and fuel oil should not be figured into the calculation to determine the percentage of oil upon the ore. The opinion asks:

> Does the use of a more efficient, in combination with a less efficient, oil of the patent constitute infringement, where the former is used in an amount within the limits of the claims but the combined amount is in excess of such limit, and when the amount of the more efficient oil used would probably produce better results from the process than are produced with the combination of oils?

Without quoting fully all of that part of the opinion conveying the answer to the above we would state that it is based upon the scope of the claims as well as upon a consideration of the state of the prior art at the time the patent was made, the court saying among other things:

> We held in the former case that the patentees came late into the field of ore concentration investigation and that their discovery rests upon a prior art so fully developed that it was "clear from the record that approach was being made slowly but more and more nearly to the result which was reached by the patentees of the process in suit in March, 1905," and that their final step was not a long one.
>
> Such a patent, in such a field of investigation, must be construed strictly, but candidly and fairly, to give to the patentees the full benefit, but not more, of the disclosure of their discovery which is to become part of the public stock of knowledge upon the expiration of the patent period, and which was the consideration for the grant to them of a patent monopoly.
>
> From this consideration of the terms of the patent as written, it is apparent that it makes no differentiation whatever, either in the claims or in the specification, among the oils having a preferential affinity for metalliferous matter, and that its disclosure, to which the petitioners must be limited, is that when a fraction of one per cent on the ore of any such oil is used in the manner prescribed there will be produced a metal-bearing froth, the result of the process. No notice is given to the public, and it is nowhere "particularly pointed out" in the claims, that some oils or combination of oils, having a preferential affinity for metalliferous matter, are more useful than others in the process, or that some may be used successfully and some not, or that some are "frothing oils," a designation not appearing in the patent, and that some are not. The patentees discovered the described process for producing the result or effect, the metal-bearing froth, but they did not invent that result or froth—their patent is on the process, it is not and cannot be on the result—and the scope of their right is limited to the means they have devised and described as constituting the process.
>
> That the only disclosure as to the kind and amount of oil which the patentees made to the public as necessary to the practicing of their process is that it must be an oil and oily substance, or oily liquid having a "preferential affinity for metalliferous matter," and that it shall be limited in amount "to a fraction of one per cent on the ore."

From the above quotations it is to be seen that the Supreme Court reverses the Circuit Court of Appeals as to its finding with respect to the use of oil between one-half of one per cent and one per cent, but sustains that court as to the non-infringing nature of the defendant's use of oil in excess of one per cent. It reverses the District Court as to Judge BOURQUIN'S opinion regarding the distinction between "frothing oils" and "non-frothing oils" in the most emphatic manner saying:

> To give such a construction to the patent would subordinate the clear description contained in it of what are oils of the process, to an implied and vague description and classification which would leave the whole subject again at large, to become a field for further experimentation, without definition in the patent of what oils or froths would satisfy it.

Referring to the evidence which had led it to the above decision, the Supreme Court says:

> Much of this evidence is especially impressive because the papers from which it is derived were written and the witnesses testified before the question as to petroleum, now made in this case, was raised or discussed.

This apparently imputes a change of front upon the part of Minerals Separation made to meet the exigencies of the case. Such a change of front is also found in Minerals Separation's reducing the violence of agitation as described in the Hyde case in an effort to conform the same patent to the conditions of the pneumatic cell.

A careful reading of this opinion with its numerous phrases emphasizing the necessity of confining the patentees to the "means" of the process as set forth in the patent claims would seem to make it of even greater embarrassment than the Hyde opinion appears to have been when applied to the pneumatic cell. All of the citations to cases made in this opinion as applied to the quantity and character of oil covered by the claims, it seems to us, would apply with equal force to the scope of the claims as to the manner of introducing air bubbles into the mass, which is the question involved in considering the application of patent 835,120 to the pneumatic cell.

The decision is against the Butte and Superior Company in that it brings that company to an accounting for its use of oil in quantity less than one per cent in a process of which the decision says, "In other respects its methods were substantially that of the patent in suit."

Promise of Progress In Rubber Research

THE organization of a Rubber Chemistry Division of the American Chemical Society is to be hailed with favor and all good wishes. The industry has thrived in this country, and it has produced vast wealth, but this has been the result of circumstance rather than because of wisdom and vision within the manufacturing organizations. Some manufacturers have always been progressive, but not all of them, by any means. Most of them employed chemists because they had to, and if

these men could get time off to visit meetings of scientific and technical associations they were usually under instructions to sit still and say nothing, but to bring back whatever they could learn of their competitors' methods and practices.

That is supposed in some quarters to be the very peak of diplomacy and astuteness. When a man of high authority in a manufacturing corporation conceives a thought of that nature his chest swells, and all his little admirers call him a wonder and declare that nobody can beat him! But in the brotherhood of American chemical industries rubber has been scientifically backward, and this is not the fault of the chemists. There has been a lack of men of scientific training on the boards of directors, and, as we have said before and expect to say again, it requires more than business acumen to see the light of science.

It is high time for the rubber industry to take a hitch in its belt and dig into the philosophy of rubber chemistry. The Division provides a start. We shall have now to meet the question whether the authorities will see clearly enough beyond the walls of their works to understand that the way to get ahead is to work together, to permit and encourage chemists to work at research, and to make known their findings. We doubt if there is a single establishment far enough ahead of the game to meet real, intensive research if the manufacturers of some other country should awaken to its value.

In this connection we are always fond of recalling a statement of Dr. JAMES DOUGLAS in one of his "Non-Technical Essays on Technical Subjects," to the effect that those who close the door against the release of information simultaneously raise an equally effective barrier against any knowledge filtering in. The rubber industry of today can learn a profitable lesson from a comparison of present conditions in the iron and steel industry with those of the "good old days" before the spread of technical knowledge.

The Duration Of Prosperity

IF THE steel industry is really the barometer of general trade, it is unfortunate that the barometer cannot be read more closely. For fully a month there have been improved conditions as to steel demand, yet it is uncertain whether the improvement represents merely a delayed spring buying movement or the beginning of a general movement of major proportions.

As to trade in general, it is now rather widely admitted that there is no occasion for men to wait for much lower prices before making purchases or investments. Price deflation has not occurred to any extent and is practically certain not to occur in the present order of things. What occurred after the Civil War is likely, in a general way, to be repeated. There was no price readjustment, to speak of, after the Civil War, but eight years later there came a great panic and then a severe industrial depression of five years' duration.

Many men are now of the opinion that business after the Great War will follow somewhat the same course. This may be a reasonable and correct conclusion, but some men are disposed to apply this conclusion to their conduct in a way that may prove very dangerous. They assume, first, that there will be a gradual deflation in prices and, second, that they will be able to discern the impending depression in time to "get out from under." Now the fact is that the course of iron prices after the Civil War shows conclusively that such a doctrine is very dangerous.

In the first place, there was no clearly marked deflation of prices during the eight years of activity that followed the Civil War, and in the second place men did not foresee the panic and depression that followed and consequently they were quite unable to save themselves.

The prices to be studied, as most indicative of the general trend in the iron industry, are the prices of No. 1 anthracite foundry pig iron at Philadelphia. Then, as now, there was a "pre-war" average of prices, but in view of the exceptionally high prices of 1853 and 1854 a five-year average, 1856 to 1860 inclusive, seems to be the fair one to take. This average was $24.37. There was no Government price control in the Civil War, and the maximum price during the war was $73.75, in August, 1864. In the spring of 1865, at the close of the war, pig iron was $50, or a trifle more than double its pre-war average.

If any one expected materially lower prices to follow the war's ending he was disappointed. There was a slight decline, but in November, 1865, pig iron was $51. Then there was a series of declines and advances, quite suggestive that pig iron was gradually sagging, the low points being successively lower. The lowest decline was to $30, in January, 1871. Then, however, any theory of a gradual and progressive deflation was completely knocked out by facts, for an advance occurred which raised pig iron to $54 in September, 1872, a price higher than obtained when the war closed more than seven years before. One year later, September 19, 1873, occurred the great Jay Cooke panic.

From this sketch of the course of the iron market, presumably as much the barometer of trade then as now, it is readily seen there was no opportunity for one to foresee and prepare for the industrial depression. More than seven years after the war ended and only one year before the panic pig iron was at a higher price than at the close of the war or at any intermediate date.

The only theory that would have saved one from loss would have been to "copper" the market, to conclude that when pig iron had reached such a level as that of September, 1872, it was time to run quickly to cover.

Equally unprofitable would it have been for any one, in 1865 or 1866, to "wait for lower prices," for one might have waited from the war's ending through seven and a half years of great activity, only to find the price higher than ever. The wait for the lowest price of all would have lasted until November, 1878, when pig iron was $16.50. That wait would have lasted more than 13 years, and one whole opportunity would have been passed. It would have paid well to take hold afresh in November, 1878, for the $16.50 pig iron of that month was followed by $41 pig iron fifteen months later.

The experience of what occurred in iron after the Civil War may or may not be suggestive of what is to occur in the next few years, but if the history of those times is to be taken as any guide at all, it should be taken precisely. One should have an exact, not a hazy and more or less inaccurate, conception of what occurred.

Readers' Views and Comments

That Missing Page From the Blue-Back Speller

To the Editor of Chemical & Metallurgical Engineering

SIR:—Referring to the editorial "That Missing Page From the Blue-Back Speller" in your issue of Dec. 15 last, and to the various comments and discussions on the same, I note that the writers in each case have a particular application in view and do not seem to apply their reasons to general practice. Yet they wish the readers to believe their statements to embody all methods of steel manufacture.

Practice has proved in some plants that the proper pouring temperature of steel is just a few degrees (anywhere from 50 to 100) above the upper freezing point. This means that with a normal size heat of about 50 tons there remains a skull in the ladle after finishing pouring.

But there are certain other practices where a skull is unnecessary, and in fact a pouring which results with skull is frowned upon. The manufacture, in some plants, of bottom-poured ingots for boiler plate is a good example of this latter practice. This steel is the effervescing kind (so named by Henry D. Hibbard), which should always be cast at sufficiently high temperature to permit the escape of considerable amount of gases from the metal during teeming and for several minutes after the molds have been filled. For this practice, then, it is necessary that the metal be so hot as not to permit any resultant skull in the ladle.

With this practice it has been found fitting and proper that the cold additions be made in the ladle instead of in the furnace. When these additions are made in a very fine stream to the metal flowing from the spout the difficulty is eliminated of the steel freezing about the cold solid particles of ferromanganese and the necessity of remelting the combination before the manganese becomes of service. Furthermore, when the ferromanganese is added to the stream of metal from the spout, and when the metal is hot enough to leave no skull in the ladle, there is never any fear of the manganese being unevenly diffused throughout the heat.

By adding ferromanganese to the ladle it is done at a time when the oxidizing influence of the slag and the reducing action of the flame have been removed. The metal is in a passive or neutral state. The stage is, therefore, set for the full and complete reducing action of the manganese. Its whole influence is exerted on the oxides and sulphides in the metal and a clearer, less oxidized metal results. What reduction takes place then is not undone by the slag, such as invariably occurs to a limited extent when additions are made in a basic furnace.

It is felt that the greater loss of manganese, stated by a recent writer, occurring when the ferromanganese is added to the furnace is due not primarily to the activity of the manganese in removing the oxygen, but this loss is due to the oxidizing effect of the slag on the element.

As was stated at the beginning of this article, each discussion on the above topic has been from one specific point of view, but each writer felt he had covered the ground as general practice. I myself have laid before you another specific practice, but I do not wish to generalize it.

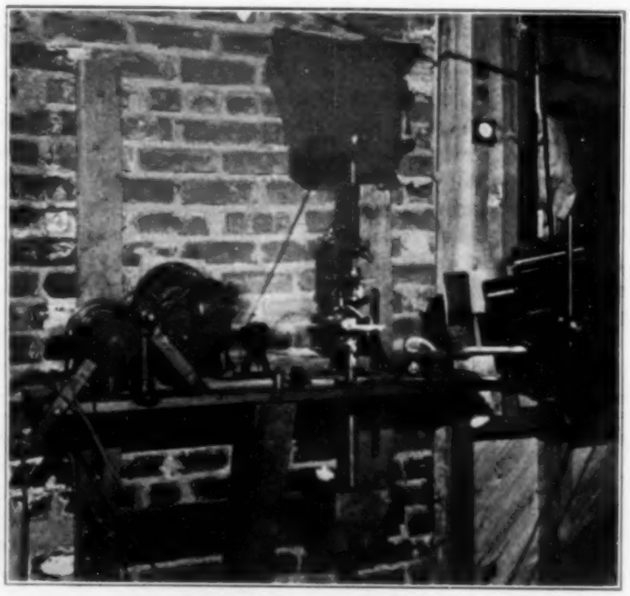
My story is not to criticise the practices as brought forward by the several writers, but merely to make plain that the conditions of manufacture are the underlying principles with regard to the addition of cold solid additions in the ladle and that the "Missing Page" must be supplied according to the requirements of the individual practice. A. L. MEYER.

Coatesville, Pa.

Photography in Research

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have noted with interest the article in your recent issue descriptive of an application of microscope and motion picture camera to the structure of steel under stress. It may be of interest to your readers to know that a similar combination of apparatus has been used by the writer for some five years past in the study of the setting processes of concrete as affected by temperature and other variables; the manner in which cement attaches itself to sand and to stone; the processes incident to attack by fresh and sea water on concrete; disruption by frost; stressing and disruption of concrete



MOTOR-DRIVEN APPARATUS FOR TAKING PHOTOS AT REGULAR INTERVALS

under strain; shrinkage and crazing through evaporations; the effect of temperature; humidity, etc.; on rusting of steel (rust is disclosed as a phenomenon of rare beauty); the oxidizing and deterioration of paints and protective coating; and various other matters of professional interest to me. As a result of these studies, new processes which give promise of wide usefulness are nearing commercial success. A lecture with such films as relating to concrete has been delivered at various places this year and seems materially to have assisted the understanding of auditors as regards these usually obscure and unknown processes.

For the taking of accurate studies, in all of which time enters as a most important factor, the hand-actuated camera shown in your illustration was early discarded. In its place, the motor-driven apparatus shown in the

illustration herewith was constructed from stock gears and a $10 camera of early vintage. By its means, pictures may be taken at any desired intervals from $\frac{1}{10}$ second to 3 hours between exposures, unvaryingly, day and night over protracted periods. Furthermore, as this has been a diversion as well as a serious study, the use of automatic means has permitted attendance on other duties without interruption.

I would further say that the use of oblique illumination of opaque objects and of dark ground illuminator for transparent or semi-transparent subjects extends the range of research far beyond those included within the possibilities of vertical illuminators.

The general scheme is an admirable tool. Let us hope for its early and general extension of use.

New York City. NATHAN C. JOHNSON.

Modification of the Cyanide Method for the Estimation of Nickel in Steels

To the Editor of Chemical & Metallurgical Engineering

SIR:—The method, as outlined below, is the common cyanide method, using ammonium citrate to hold the iron in ammoniacal solution—with several differences. The differences are the method of introduction of the silver nitrate into the solution to be titrated and the elimination of hydrochloric acid in dissolving the steel.

It is a fact not generally known among iron and steel chemists that silver nitrate is soluble in concentrated potassium iodide solution, due to the formation of a double salt. (See Prescott and Johnson, Qualitative Analysis.) This double salt breaks down to silver iodide and potassium nitrate on dilution. This modification takes advantage of these facts by the use of an indicator solution containing silver nitrate and potassium iodide, the only precautions being necessarily the use of this indicator in definite quantity in each determination and the determination of a blank, to be subtracted from each titration.

The method as at present in use in this plant is:

Weigh a 1-g. sample into a 250-cc. beaker, dissolve in 30 cc. nitric acid (1.20 sp.gr.) and evaporate to 8 or 10 cc. Remove from the hot plate and add 50 cc. sulphuric and citric acid solution. Cool, make faintly but distinctly alkaline to litmus paper with ammonia and dilute to 150 to 175 cc. Cool to room temperature, and add exactly 2 cc. special indicator, from a pipette or a burette, and titrate with standard potassium cyanide solution until the solution just clears.

SPECIAL INDICATOR

0.2925 g. Silver nitrate
30.0 g. Potassium iodide
Distilled water to make the volume 100 cc

SULPHURIC AND CITRIC ACID SOLUTION

200 g. Citric acid
600 cc. Distilled water
400 cc. Sulphuric acid (1 to 3)

STANDARD POTASSIUM CYANIDE SOLUTION

4.5 g. Potassium cyanide (or equivalent in sodium cyanide)
1000.0 cc. Distilled water
5.0 g. Potassium hydroxide may be added, but is not necessary.

Standardize by putting 1 g. of a standard steel through the above manipulations. A blank, representing the amount of standard solution necessary to clear 2 cc. of the special indicator, must be deducted from all titrations. This blank is best determined by running a nickel-free steel through the method, but diluting 2 cc. of the special indicator to 150 cc. with water, and titrating, will be sufficiently accurate for routine work.

Anderson Forge and Machine Co.
Detroit, Mich. L. F. MILLER.

Western Chemical and Metallurgical Field

Pig Iron, Ferros and Sponge Iron at Heroult

IN VIEW of the fact that the Noble Electric Steel Co. has been a pioneering experimenter in electric pig iron on the Pacific Coast, its friends will be glad to know that its most recent investigations on low-temperature reductions have been very encouraging, and entirely successful in a small-scale unit.

Electric smelting was commenced by this company in 1907 under the direction of H. H. Noble, when the late Dr. Paul L. T. Heroult constructed a 2000-hp. rectangular furnace with arched roof, having three electrodes alternating with four vertical charge chutes. Escaping gases were led upward through these chutes to preheat and reduce the ore, but in operation the heated ore hung in the chutes, and a very hot top melted the roof. Some iron was made in this early furnace, but a single-phase furnace of 160 kw. was built in 1908 under direction of Dorsey A. Lyon, and this was followed the next year by a tall shaft furnace (quite similar to the independently developed Swedish type), whose operation continued intermittently two years. With the latter it was found extremely difficult to control the carbon in the resulting pig iron (soft, high-silicon foundry iron was desired by the available market), since excess carbon could not be burned off, and deficiencies of carbon and segregation of constituents often occurred during settlement of the charge. Long, narrow, closed-top furnaces of 2000 and 3000 kw. capacity similar to Dr. Heroult's were therefore built in 1912, and continuously operated without preheating the ore in the charging chutes. John Crawford described the results from these furnaces in METALLURGICAL & CHEMICAL ENGINEERING, July, 1913, Vol. XI, p. 383. Iron containing 2.9 per cent Si, 0.1 per cent combined carbon and 3.4 per cent graphitic carbon was made with a minimum power consumption of 2200 kw.-hr. per ton (0.40 hp.-yr. at 85 per cent load factor).

Other circumstances than undeveloped technology militated against the success of the Noble Steel Co. Its plant is situated in the northern part of California in mountainous country removed by long rail haul from the source of the company's miscellaneous supplies and its market. Ore and flux are near by, but the timber was rapidly exhausted. As a last straw, the men most interested in the steel company lost control of the Northern California Power Co. in 1914 and their rates for energy immediately doubled, forcing a closure of the plant as far as the commercial production of pig iron was concerned. A very good quality of pig iron was made in one of their open pit furnaces in a campaign during the months of January and February of the present year. This furnace had an open top, and had been used to produce various ferro-alloys. Over 95 per cent of the iron in the ore charged was recovered as metal with a power input of 2400 kw.-hr. per short ton of pig iron.

As an offset to the many disappointments as iron producers, the following brief record of successful alloy practice should be made:

In 1907, Petinot, using the original Heroult furnace, made ferrosilicon, and plans were made for the production of ferrochromium. Owing to the lack of a ready market for the alloys, this work was set aside, and all effort concentrated on the iron problem during the following seven years.

In the fall of 1914, Crawford made ferromanganese in the furnaces described by him in METALLURGICAL & CHEMICAL ENGINEERING, Vol. XI, p. 383, but he was unable to co-ordinate the electrical and metallurgical conditions of the burden in a closed-top furnace, and still produce a standard alloy with the low-grade ore supplied him.

In 1915, Scott, followed by Gosrow, using the smaller Crawford furnace with the top removed, established a good furnace practice on ferromanganese with ore of standard specification. They were forced to discontinue operations, however, when the grade of ore fell off.

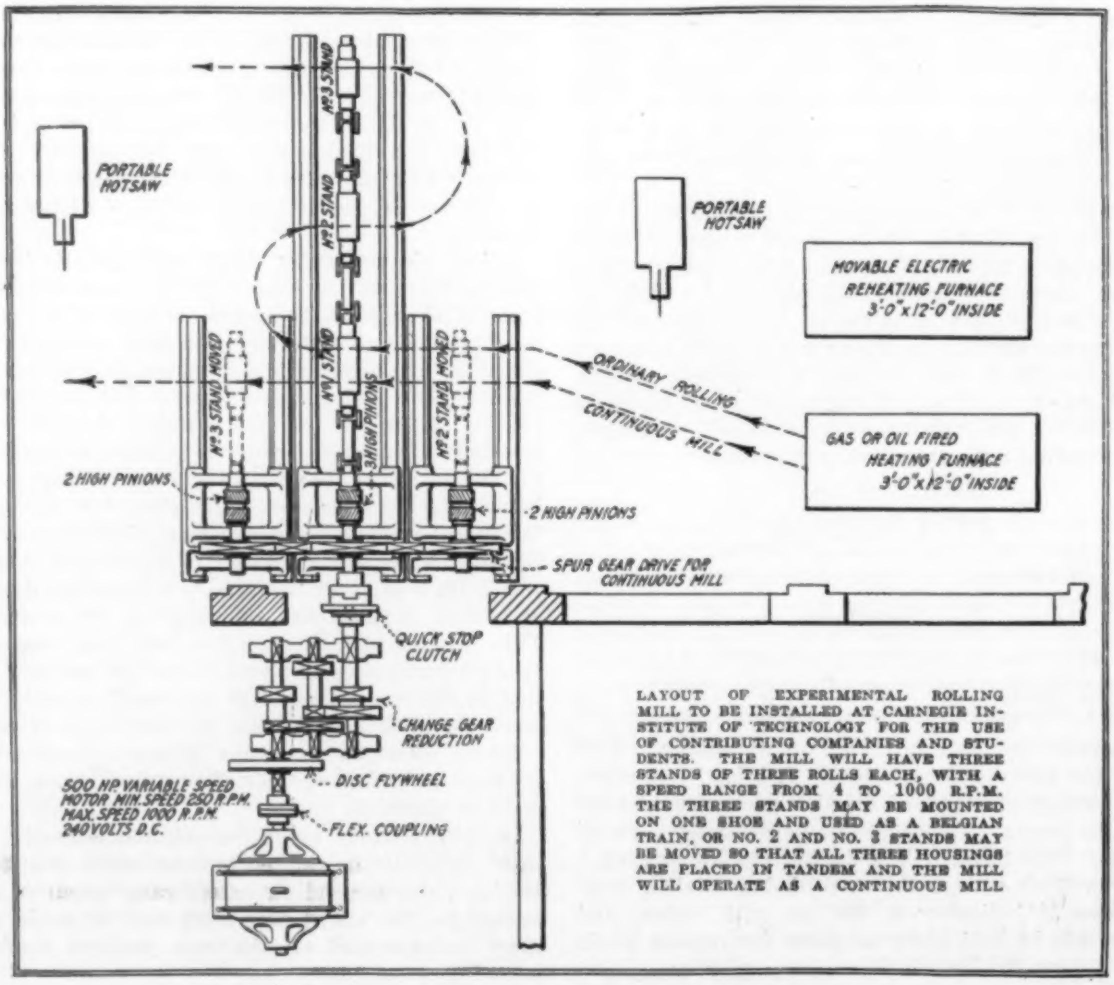
From April, 1916, until March, 1919, the plant ran continuously on ferro-alloys, with operations varying in volume from one to four furnaces, as raw materials could be obtained. During this period, ferromanganese was the main product, and ferrosilicon, ferrochromium, silicomanganese and pig iron were produced in small amounts when the demand was strong. During these latter operations, the problem of low-temperature reduction of iron ores was approached—not an entirely new venture to the Noble company, since about seven years previously, in 1911, it installed a series of small portable electric furnaces for making sponge iron, and a large tilting type (2000-kw.) furnace for melting. A mechanical device, similar to the open-hearth charging machine, periodically emptied the contents of a small furnace into the melter. Mechanical difficulties and lack of metallurgical control soon caused the abandonment of this experiment, however.

Recently these attempts were revived in view of the large increase in power cost. It is essential to reduce its consumption if electrical smelting is to succeed, and the most promising method seemed to be to separate the reduction stage from the melting stage.

According to Dr. Stansfield's recent report on the commercial feasibility of the electric smelting of iron ores in British Columbia, reduction can be done at 700 to 800 deg. C., and absorbs about twice as much heat as the actual melting, which involves a high temperature—1400 to 1600 deg. C. In a combination process, electricity might be used for the development of the high melting temperatures only, for which it is most efficient. In this manner, simple melting can be done with 600 to 700 kw.-hr. per ton, while reduction followed by melting requires nearly four times as much power.

Dr. Trood and Mr. W. A. Darrah carried out a series of experiments following this idea at Heroult last year, using the Noble Steel Co.'s pure magnetite. The work was done in a small furnace, electrically heated, making a few pounds of reduced iron per hour. Reduction of magnetite by powdered charcoal commences in the neighborhood of 700 deg. C., but commercially it would appear to be advisable to speed up the reaction by operating nearer 800 deg. C., at which it requires about three hours effectually to reduce ore particles the size of coarse sand. The resulting sponge can then be melted electrically to either pig iron or steel, or, after briquetting, melted in a gas-fired open-hearth furnace.

From these rather small-scale experiments, Mr. Darrah



LAYOUT OF EXPERIMENTAL ROLLING MILL TO BE INSTALLED AT CARNEGIE INSTITUTE OF TECHNOLOGY FOR THE USE OF CONTRIBUTING COMPANIES AND STUDENTS. THE MILL WILL HAVE THREE STANDS OF THREE ROLLS EACH, WITH A SPEED RANGE FROM 4 TO 1000 R.P.M. THE THREE STANDS MAY BE MOUNTED ON ONE SHOE AND USED AS A BELGIAN TRAIN, OR NO. 2 AND NO. 3 STANDS MAY BE MOVED SO THAT ALL THREE HOUSINGS ARE PLACED IN TANDEM AND THE MILL WILL OPERATE AS A CONTINUOUS MILL

estimates the cost of sponge iron at $19 per ton. His items for crushing, handling and labor are possibly somewhat optimistic, while charcoal costs, though apparently very high, are still considerably less than the present market in those regions.

His items are as follows:

Item	Cost	Quantity Required	Total Cost per Ton of Iron
Power for drying and reduction	½c. per kw.-hr.	1,200 kw.-hr.	$6.00
Charcoal	$25 per ton	570 lb.	7.10
Ore	$3 per ton	2,760 lb.	4.15
Crushing materials	50c. per ton	....	.69
Handling materials	50c. per ton	....	.69
Labor and supervision	....	....	.50
Interest and depreciation on $20,000 investment	....	....	.10
Total			$19.23

In commenting on these figures, Dr. Stansfield notes that the charges appear very small, but are perhaps not underestimated, owing to the continuous nature of the mechanical operations and the small amount of labor required.

Accepting Mr. Darrah's figures, Dr. Stansfield compares the cost of a ton of foundry iron by the direct process to that of white iron in a Swedish furnace (British Columbian conditions) as follows:

	FOUNDRY PIG FROM SPONGE IRON			WHITE IRON IN ELECTRO-METALS FURNACE		
	Plant Capacity 36,500 Tons Yr.	Rate	Amount	Plant Capacity 27,000 Tons Yr.	Rate	Amount
Ore	2.2 tons	$4.00	$8.80	2 tons	$4.00	$8.00
Crushing	2.2 tons	.50	1.10	....	.....	....
Handling	2.2 tons	.50	1.10	....	.....	....
Producer gas for reduction	Coal at $4	.....	2.50	....	.....	....
Charcoal for reduction	⅓ ton	6.00	2.00	....	.....	....
Labor and supervision	....	.....	.85	....	.....	....
Interest and depreciation	....	.....	.25	....	.....	....
Total for sponge iron by gas	....	.....	$16.60	....	.....	....
Electric power	750 kw.-hr.	0.5c.	3.75	2500 kw.-hr.	0.5c.	12.50
Charcoal	0.1 ton	6.00	.60	0.4 ton	8.00	3.20
Electrodes	7 lb.	8.5c.	.60	15 lb.	.08	1.20
Fluxes and supplies	....	.....	.55	....	.....	....
Repairs and maintenance	....	.....	.....	....	.....	1.00
Labor and supervision	....	.....	3.00	....	.....	6.50
Interest and depreciation	....	.....	1.50	....	16%	2.60
Royalty	....	.....	.....	....	.....	0.50
Total cost			$26.60	....	.....	$35.50

Steel Research Laboratory

It was announced in April that Prof. W. Trinks of the Carnegie Institute of Technology had secured the interested co-operation of a number of steel companies and equipment manufacturers in the Pittsburgh district in organizing a Bureau of Rolling-Mill Research. This bureau will be under the direction of Mr. W. B. Skinkle and supported by funds advanced by the co-operating firms. The accompanying sketch of the proposed installation is self-explanatory, and immediately suggests the wide range of data which can be secured.

Adequate indicating instruments will be installed, so that not only the metallurgical results but the main stresses in the stands, rolls and pinions may be studied during variation in the speed of rolling, the degree of reduction, the diameter of rolls, the shape of the pass, or the analysis and temperature of the steel.

This bureau, in addition to its program of studies such as noted above, will distribute the derived information to the contributing firms for commercial exploitation, and will provide facilities for special researches by their engineering staffs, as well as constituting a laboratory of instruction for regular and special students at Carnegie Tech.

Company Reports

Calumet & Arizona Mining Co.—The smelter at Douglas operated continuously, but on a reduced ore tonnage, amounting only to 68 per cent of capacity. Ore receipts are continually decreasing in oxidized mineral, and in case proper and economical crushing arrangement can be worked out, all the material will be roasted and sent to reverberatories, practically disusing the blast-furnace department. During 1918 376 blast-furnace-days smelted 313,695 tons of dry charge, compared to 602,272 dry tons treated in 1065 reverberatory-furnace-days. Header flues for the latter furnaces were rebuilt of refractory brick to larger dimension, directly increasing the smelting capacity 40 per cent. Some blast-furnace jackets in continuous service since June, 1913, were replaced owing to corrosion of the water surfaces, the inner face exposed to the heat showing very little wear.

New Cornelia Copper Co.—This company has completed its first full calendar year as a producer of copper. During this year all bonds were converted into stock, the greater part of the indebtedness liquidated, and a first dividend of 25c. per share paid. Production was as follows:

Electrolytic cathodes	31,264,642
Cement copper	10,990,666
Copper in ore shipped	4,694,831
Total	45,950,139

Operating and general expenses, freight, refining, selling, taxes, interest and depreciation amount to $7,490,000, a total of nearly 16c. per pound. Apparently about 13,000,000 lb. of this copper was on hand at the end of the year, or more than a quarter's output, so operations were curtailed to 60 per cent of capacity on Feb. 1, 1919. In order to increase the plant to a monthly production in excess of the 3,000,000 originally designed, a fourth motor-generator set for electrolytic power is being installed. a fifth unit of 3 Symons disc crushers added to the fine crushing plant, the SO_2 reduction capacity doubled by the addition of two large towers. Nearly 1 lb. of copper per ton was saved by giving the leached ore five instead of four wash-waters. It is anticipated that the mine will be able to produce 5000 tons daily of sulphide ore (1.6 per cent copper) within three years. Consequently $160,000 was appropriated for a 500-ton test mill to determine largely the proper method of grinding the ore and the correct flotation practice. This mill is now nearing completion. "The operation of the New Cornelia Co-operative Mercantile Co. was very successful. A discount of 15 per cent on purchases for the year was paid to 773 employees."

American Smelting and Refining Co.—This company was able to accumulate earnings applicable to dividends of $7,700,000 despite the pessimistic statement of President Daniel Guggenheim in the preceding report that "By these two governmental actions, first, by reducing the value of our product, and, second, by constantly increasing our cost, this great corporation . . . is having its ability to pay a fair return to its stockholders seriously jeopardized." The report for 1918 further recites that during the last three years nearly $20,000,000 has been expended for new property and construction in addition to renewal of absolescent construction, the cost of metals carried has increased over $17,000,000, and the demand on excess cash resources further increased to a total of over $42,000,000 by Liberty Bond holdings, all of which have been met without necessity

of borrowing. The board of directors may thus be pardoned their justifiable pride in their conservative management. "A comparison of the condition of the company in 1902 and of the two companies [A. S. & R. Co. and American Smelters Securities Co.] will be instructive, the figures given in the following table being approximate only:

	1902	1918	Increase, Per Cent
Quick assets	$18,000,000	$50,000,000	175
Profit and loss account	2,900,000	27,000,000	816
Annual turnover	82,000,000	390,000,000	372

Further quoting from the report, "The most discouraging condition during the war years has been the great increase in our costs of smelting and refining, while the company was without power to correspondingly increase the charges to the mines for doing this work. But these costs are already considerably decreased, and although pre-war costs may never be realized again, the board does expect that pre-war profits per ton of ore smelted will be obtained as soon as normal business is resumed."

Inspiration Consol'dated Copper Co.—Successful operations continued despite a shortage of labor and a corresponding decrease in its efficiency; comparative mill statistics are as follows:

	1916	1917	1918
Tons milled	5,316,350	3,891,075	5,110,101
Average rate per section	897.8	936.7	956
Mill feed, per cent copper	1.548	1.388	1.361
Mill tailings	0.397	0.355	0.380
Flotation concentrates, per cent copper	37.50	35.57	35.26
Sulphide recovery, per cent	90.95	89.73	88.51
Gallons water per ton ore	226	348	310
Ball consumption, lb.	1.76	1.82	1.82
Flotation oils per ton, lb.	1.287	1.32	1.35

Nipissing Mines Co., Ltd.—High-grade ores have been treated for seven years by an amalgamation process using large quantities of mercury. The war-time increase in price from about $35 to $130 made this process so expensive that it was decided to rely upon cyaniding alone, after giving the ore a preliminary treatment with bleaching powder in the tube mill. The necessary apparatus for this change was installed in the low-grade mill, and the high-grade mill shut down about the middle of the year, but will probably be revived as soon as the price of supplies justifies the step. In the low-grade mill at present the ore is crushed by stamps in cyanide solution and sent to the roughing tables without classification. The tailing from the tables is classified, the sand being recrushed in tube mills, and the undersize sent to the fine sand tables. The tube mill discharge is returned to the classifier, while the tailing from the fine sand tables is cyanided. By this method 48 per cent of the silver is recovered in the form of a concentrate, 40 per cent as precipitate from the cyanide plant, and 12 per cent is lost. The concentrate is retreated in the high-grade mill with high-grade ore, and the precipitate from both treatments is sent to the refinery, where it is converted into bullion. This process can give a better extraction at a lower cost than can be obtained by cyanide alone on the present quality of ore, due consideration being given for the value of the cobalt in the concentrate.

United States Smelting, Refining & Mining Co.—Operations in Mexico appeared to have run on a normal basis, the two mills at Real del Monte and Pachuca having treated 690,000 tons of ore. This tonnage will be increased to about 80,000 tons per month on completion of additions now under construction. In Utah, on account of the abnormally large ore supply available at the Midvale plant, it was found advisable to enlarge the installation by one blast-furnace. For a short time all seven of these furnaces were in operation, but for the remainder of the year one or two of them were down. The zinc operations were not so successful, since a failure in the gas supply caused the closing down of the Checotah smelter early in the summer. The Mammoth smelter at Kennett, Cal., operated throughout the year at capacity, in spite of difficult conditions in labor and material supply. Experiments have continued on the new electrolytic zinc process, but production cannot be expected until more favorable market conditions occur. Construction of the surface plant at Sunnyside was completed, and the mill gave promise of fulfilling all expectations. This plant was seriously damaged by fire within the past few weeks, however.

Consolidated Arizona Smelting Co.—A program of reconstruction started four years ago was practically brought to completion during 1918 with results in operation fully justifying preliminary estimates. For instance, the new roadster plant and its accessories, costing a total of about $300,000, has saved approximately $100,000 in improved metallic extraction during the first year, in addition to an operating economy of about $150,000. There is apparently little justification in maintaining antiquated departments when a modern design nearly pays for itself in 12 months. Improvements in reverberatory smelting have increased the capacity to a point where blast-furnace smelting had been discontinued, and notwithstanding large increases in cost of labor and supplies (especially fuel oil) and a corresponding increase in mining and milling costs, copper was produced in 1918 for 14.683c. per lb. as against 14.98c. in 1917.

Phelps-Dodge Corporation—The following is a tabulation of the milling data contained in the last annual report:

	Moctezuma	Burro Mountain	Morenci
Dry ore milled, tons	762,029	585,083	449,990
Copper content	3.392%	1.928%	1.910%
Tailings	0.627%	0.630%	0.519%
Extraction	85.6%	70.2%	76.2%
Gallons fresh water per ton	666	737	......
Kw.-hr. per ton	12.54	10.16	......

At Burro Mountain the proportion of sulphide copper in the ore decreased to 1.65 per cent, which caused a slight drop in sulphide in tailings to 0.44 per cent. Extensive experimental work has developed the fact that fine grinding in closed circuit, more flotation units and additional tables below flotation will increase this extraction, and plans are being drawn up for a corresponding revision in the flow sheet.

Stripping operations on Sacramento Hill (Bisbee District) have been about 30 per cent completed, and at the present rate a daily production of 4000 tons of ore can be maintained within 18 months. The new concentrator for this service was designed under direction of H. Kenyon Burch, but its construction has been postponed until market conditions are more favorable.

Fall Meeting of the American Electrochemical Society

The next meeting of the American Electrochemical Society will be held in Chicago, Sept. 23 to 25 inclusive, during the week of the National Exposition of Chemical Industries. This Middle West meeting in conjunction with the Exposition affords a combination of circumstances which will undoubtedly bring a large attendance. Work on the program is actively under way by the officers of the Society and a symposium on catalysis is being arranged as a special feature.

Electric Power Production

THE following table is based on a report issued by the Geological Survey for the month of February, 1919. Returns were received from 3150 electric power plants engaged in public service, including central stations, electric railways and certain other plants the output of which contributes to the public supply. As these returns represent 85 per cent of the total capacity, estimates of output were made from available information for those plants which did not make returns or which were unable to furnish the data requested.

ELECTRIC POWER PRODUCTION MONTH OF FEBRUARY, 1919

State	Capacity, Kw.	Thousands of Kw.-Hr. Produced By Water-Power	By Fuels
Alabama	165,688	39,372	12,939
Arizona	91,363	3,967	16,395
Arkansas	32,358	77	6,275
California	852,956	190,462	38,295
Colorado	131,027	13,161	17,271
Connecticut	252,130	12,419	38,643
Delaware	20,617	0	5,549
District of Columbia	66,450	0	18,094
Florida	59,304	678	11,257
Georgia	214,250	35,497	7,236
Idaho	115,439	42,050	259
Illinois	804,329	13,701	241,930
Indiana	319,348	3,761	56,151
Iowa	291,635	44,214	23,110
Kansas	156,114	1,267	29,203
Kentucky	104,889	4	18,900
Louisiana	52,639	0	14,034
Maine	92,927	16,611	132
Maryland	128,879	278	18,448
Massachusetts	748,698	19,147	102,844
Michigan	476,913	49,980	97,187
Minnesota	292,935	24,525	28,708
Mississippi	34,315	0	5,789
Missouri	291,170	4,297	37,212
Montana	237,476	69,220	1,552
Nebraska	90,462	810	16,022
Nevada	10,630	2,913	137
New Hampshire	47,938	4,660	2,188
New Jersey	343,214	165	79,153
New Mexico	12,830	59	1,272
New York	1,836,029	204,590	288,986
North Carolina	172,217	43,234	2,820
North Dakota	20,939	0	2,308
Ohio	829,161	2,309	181,766
Oklahoma	68,013	223	12,092
Oregon	112,008	27,034	3,259
Pennsylvania	1,132,174	55,066	243,098
Rhode Island	159,175	383	28,767
South Carolina	195,192	64,745	3,235
South Dakota	34,449	4,624	3,751
Tennessee	170,272	43,780	8,368
Texas	202,101	165	43,151
Utah	76,832	48,906	0
Vermont	86,071	13,777	209
Virginia	186,150	17,693	17,685
Washington	275,802	71,160	5,667
West Virginia	187,556	1,453	51,584
Wisconsin	351,215	28,284	32,709
Wyoming	21,031	251	3,542
Total	12,665,309	1,220,972	1,879,182
Combined total	....	....	3,100,124

The power produced by fuels (1,879,182,000 kw.-hr.) resulted from the combustion of 3,007,815 short tons of coal, 662,770 bbl. of petroleum and derivatives and 1,693,401,000 cu.ft. of natural gas.

Dedication of New Bureau of Mines Laboratories

The Bureau of Mines announces that during the week of Sept. 29 the new million dollar laboratories and workshops in Pittsburgh, Pa., will be formally dedicated. High officials of the Government, together with the Governors of the principal mining States and the leaders in the mining industries and miners' organizations, will be present to take part in the dedicatory ceremonies. A feature of the dedication will be a great national Safety-First meet, teams of miners from all over the country competing for cups and medals. There will be contests in rescue work and in first aid to the injured, and as there is immense rivalry between the teams of the different mining companies, it is expected that these contests will take at least two days for decision. On Sept. 30 the elimination contests will begin at Forbes Field in Pittsburgh and will continue until only the winning teams are left for the final championship contests, which will take place on Oct. 1 immediately after the elimination trials are completed.

The different laboratories of the bureau have been completely equipped for the investigation of the various problems relating not only to greater safety, but also to greater efficiency in the mining and metallurgical industries. Visitors will be invited to the electrical and mechanical workshops and laboratories of the bureau and also to the petroleum, gas and coal laboratories, the testing gallery of the mine safety section, and the industrial gas-mask division. Another point of interest will be the experimental mine of the bureau at Bruceton, Pa., twelve miles from Pittsburgh, where an actual explosion of coal dust in the mine will be staged for the benefit of those attending. At the experiment station there is also to be shown a complete exhibit representing the mining and metallurgical industries of the country.

April Imports and Exports

The Bureau of Foreign and Domestic Commerce of the Department of Commerce reports for April, 1919:

DOMESTIC EXPORTS OF CAUSTIC SODA AND SODA ASH FROM U. S. TO ALL COUNTRIES

Countries	Caustic Soda Lb.	Caustic Soda Value	Soda Ash Lb.	Soda Ash Value
Belgium	91,212	$3,175	......	......
Denmark	1,026,560	36,900	......	......
France	760	40	......	......
Greece	129,366	4,390	......	......
Iceland and Faroe Islands	550	30	......	......
Norway	168,925	7,438	......	......
Spain	357,462	16,399	......	......
Sweden	......	......	439,606	$22,873
British Honduras	......	......	95	6
Canada	631,149	29,600	4,387,736	98,124
Costa Rica	10,125	557	......	......
Gautemala	762	95	......	......
Honduras	19,760	889	......	......
Nicaragua	830	24	......	......
Panama	28,720	987	760	49
Salvador	......	......	1,127	39
Mexico	2,415,071	97,040	480,261	10,736
Newfoundland and Labrador	......	......	1,488	33
Trinidad and Tobago	10,700	309	400	16
Other British West Indies (exc. Jamaica and Barbados)	360	32	......	......
Cuba	1,098,409	36,055	200,025	4,593
Dutch West Indies	......	......	9,000	270
French West Indies	724	38	......	......
Dominican Republic	41,000	1,270	3,200	150
Argentina	267,700	12,820	......	......
Brazil	722,614	29,789	232,247	9,715
Chile	238,904	8,342	13,590	457
Colombia	56,155	3,957	......	......
Ecuador	17,250	528	......	......
Peru	8,038	283	21,000	740
Uruguay	167,323	7,043	......	......
Venezuela	21,715	914	1,200	72
China	228,712	10,827	......	......
British India	112,000	3,416	......	......
Dutch East Indies	251,300	10,031	48,125	1,365
Hongkong	150	29	22,395	952
Japan	585,025	23,179	72,000	2,160
Australia	191,410	14,539	24,144	870
New Zealand	31,899	2,274	......	......
Philippine Islands	7,750	509	1,000	74
British West Africa	26,880	739	1,300	35
Total	8,967,270	$364,491	5,960,699	$153,329

IMPORTS INTO AND DOMESTIC EXPORTS FROM THE U. S. BY TOTALS ONLY OF COPPER

Exports

	Tons	Lb.	Value
Copper ore	.....	....	....
Concentrates, matte and regulus	.....	....	....
Pigs, ingots, plates, wire, etc., unrefined black, blister and converter copper	.....	....	....
Refined copper in ingots, bars or other forms	.....	17,841,731	$3,019,456
Composition, metal, copper chief value	.....	90,125	29,319
Old and scrap	.....	118,084	19,608
Pipes and tubes	.....	574,149	230,739
Plates and sheets	.....	1,299,224	391,917
Wire, except insulated	.....	3,310,788	975,230
All other manufactures of	.....	....	229,100

Imports

	Tons	Lb.	Value
Copper ore	15,187	4,998,467	$978,436
Concentrates	7,666	2,374,639	374,240
Matte and regulus, coarse metal and cement	2,062	2,400,549	443,899
Manufactures of unrefined black blister and conterter copper in bars, pigs or other forms	.....	22,781,489	4,359,543
Refined copper in bars, plates, rods or other forms	.....	556,305	83,445
Old and clippings for remanufacture	.....	175,604	22,953
Composition metals, copper chief value	.....	2,323	252

Alloy Steels for Helmets and Armor

Notes on Steels of Various Compositions and of High Penetrative Resistance Used for Protective Purposes by the American Army—Details of Electric-Furnace and Rolling-Mill Practice Are Presented

BY JOHN A. COYLE

EARLY in America's participation in the war, a prominent Pittsburgh District steel company was asked to produce sheet metals for helmets, the principal specification being that a sheet 0.035 in. thick (20 gage) should withstand a .44 Colt bullet with a muzzle velocity of 840 ft. per sec. at a distance of 10 ft., point blank impact. This was successfully met—ballistic tests of this sort denting the finished helmet over a roughly circular spot of 3½ in. diameter to a depth of perhaps one-half inch.

To produce such metal, experiments were first performed upon manganese-vanadium steel produced by the steel company in its own furnaces, and with the following chemical composition:

C	0.40 to 0.50
Mn	0.80 to 1.00
V	0.20

(Silicon, sulphur and phosphorus normal.) Indifferent results attended these efforts, and no helmets were produced of this analysis; seemingly some other alloying element was needed, or else the relative proportion of those used was not exactly right.

HADFIELD'S MANGANESE STEEL

Slabs of Hadfield's manganese steel (C, 1 per cent; Mn, 12 to 13 per cent) were then procured from an outside manufacturer and sufficient sheets produced to make about 25,000 helmets. Production was slow and uncertain for a variety of causes, however, and this particular material was abandoned as non-commercial. In the first place the slabs were made from converter steel, and differed widely in quality—a very considerable quantity was returned to the maker as worthless. As received at the rolling mills, the slabs had been quenched from 1800 deg. F., after which this manganese steel could be readily rolled in ordinary mills with the heat treatment usually given mild steel. However, as the slab was reduced there was a marked tendency for the edges and corners to curl up, so that when it was necessary to pair two of them together for the final passes, the sheets could not be readily matched. This fact alone was sufficient to start a search for more workable material. A peculiar characteristic of quenched Hadfield's steel is that it shears easily but cannot be cut with ordinary lathe tools or drills. While it can be pressed cold, a limit to such working is soon reached, since it hardens progressively after continued cold work.

ARMOR OF NICKEL-MANGANESE STEEL

A nickel-manganese steel was then produced in quantity in a 6-ton Heroult furnace, a unit of the steel company's equipment, from which 106,000 helmets were successfully made without a single rejection. The analysis follows:

C	0.37 to 0.47 per cent
Mn	0.95 to 1.05 " "
Ni	2.00 " "
V	0.15 to 0.25 " "
Si	0.15 to 0.25 " "
P	0.02 max. " "
S	0.02 max. " "

This material worked very readily—the product after annealing being a dead-soft sheet which could be bent flat upon itself in any direction without sign of fracture. No difficulty was experienced in the sheet mills when following the usual mild-steel practice; the final workable annealing was done in pots at 1700 deg. F. for 10 hours, cooling in the furnace requiring 14 hours to reach 60 deg. F. In such condition the sheets could be readily straightened and trimmed after ordinary methods.

An Indiana enameling and stamping company shaped the helmets to pattern provided by the Government. Originally it was intended to do this in four operations, each separated by an annealing in a continuous furnace some 26 ft. long, heated by side gas-burners to a degree just below recalescence. Passage through this furnace required 3 min., and such treatment apparently relieved any cold-working strains entirely. About 2000 helmets were made in this manner, when experiments demonstrated that the entire shaping could be done in one draw without endangering the impact resistance of the finished helmet. The balance were made in that manner, therefore, the annealing for strain described above being followed by oil quenching from 1500 deg. F., and drawing in oil at 450 deg. F., which practice produced a satisfactory helmet. Another contractor ruined a few of these helmets by a little heat during a sanding and baking operation, but this practice was soon remedied.

With the problem of commercial production of helmets solved, attention was next turned to an armor required by the army, which, when 0.175 in. thick, would resist penetration by a copper covered bullet from a Springfield rifle (muzzle velocity 2140 ft. per sec., range 50 yd.). Some of this specification was produced from metal with the analysis first given—that is, 0.45 carbon, 0.90 manganese and 0.20 vanadium—but apparently a little variation in the chemical composition had a disproportionate effect on the ballistic results. After trials it seemed that higher manganese acted somewhat as a stabilizer, and the following analysis was adopted:

C	0.37 to 0.47
Mn	0.95 to 1.05
Ni	1.85 to 2.15
V	0.15 (as a scavenger)
Si	0.15 to 0.25
P	0.02 max.
S	0.02 max.

Such material appeared satisfactory from many angles

and its quantity production was under way upon the termination of hostilities; in all 9000 tons were made by the company in question.

Melting in Electric Furnaces

As noted, the bulk of this special sheet was made in a 6-ton Heroult electric furnace, which is an ideal producing unit for making ferrous alloys of highest purity. Owing to the pressing demand, an available crucible furnace was also utilized, 24 pots of melted steel and one-half pot of liquid ferromanganese were mixed in a pre-heated ladle before casting into ingots. This was merely an expedient, however, since nearly all of this special metal was made in an electric furnace, a brief description of whose operation may therefore be of interest.

Assuming that the furnace has been fettled after a previous heat, solid charge is placed through the side doors with all possible speed, some 45 min. being required at the best. The load consists of approximately:

1700 lb. wash metal (low-phosporus pig with 3½ per cent C)
6000 lb. low-phosphorus steel scrap
5200 lb. commercial mill-scrap
A varying quantity of ferromanganese
A varying quantity of nickel, 98 per cent pure
300 lb. lime
45 lb. fluorspar

A 110-volt current is then switched on, the doors closed and melting proceeds. Surges of current in cold charged metals are more than considerable, giving up to 10,000 amperes momentarily, but the bath settles to quietness in 30 min. at most. Various systems of electrode regulation have been tried, each of which produces various results, more or less acceptable. From the time of cessation of surging current due to cold charges, melting requires about 2 hr. 45 min., during which time certain reactions are taking place in the metal, so that when the bath is completely fluid, the charge which originally totaled 1.04 carbon, 0.17 silicon, 0.045 phosphorus and 0.035 sulphur, has been reduced to 0.34 carbon, 0.035 phosphorus, 0.04 silicon and 0.030 sulphur.

Dephosphorization

Dephosphorization then proceeds to completion in a bath of moderate temperature in about 45 min. During this period the current consumption is well balanced on the three electrical phases, and while the current input is at maximum of about 450 kw. per phase, the just-melted metal, of course, takes up the heat gradually, and it is during this increase in temperature that the phosphorus is eliminated. When the temperature rises till the optical color appears, which is a white heat above pale yellow, dephosphorization ceases.

Temperature in the furnace is controlled by the eye of an experienced melter combined with his knowledge of the influence of electrical input—a method leaving much to the "personal equation" and capable of large improvement. Unfortunately, however, pyrometric science has not yet solved the problems presented by the electric furnace. Its heat is derived from radiation from an intensely hot arc, and consequently the interior is far from the black body condition demanded by optical pyrometers, while the presence of oxides or carbon films on the slags changes the emissivity factor of the bath continually. The best indication of a furnace's performance during the dephosphorization stage yet found and practiced is a continuance of the ancient slag test—a button of slag after quenching exhibits a peculiar black color and rather indescribable luster, which when recognized is a sign of good work. This physical indication is immediately confirmed by rapid chemical analysis, which is constantly the furnace operator's guardian angel.

When dephosphorization is complete, the metal will have the following approximate composition:

C	0.300 per cent
Si	0.050 " "
P	0.015 " "
S	0.025 " "

The furnace is then tilted slightly and the slag carefully and completely skimmed off through the tapping spout with the aid of wood and metal rakes. Here a word about furnace lines may be apropos. It is well

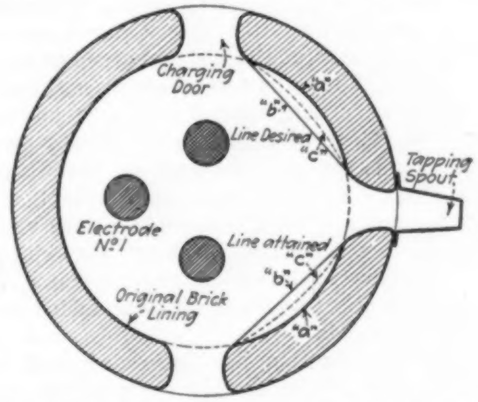


FIG. 1. SKETCH OF HEARTH OF ELECTRIC FURNACE (SECTION THROUGH SIDE WALLS)

known that if any phosphorus-bearing slag or other material remains in the furnace, the phosphorus will reenter the metal at the high temperature reached during desulphurizing, yet little attention in many so-called furnace "designs" is given to the practical problem of making all parts of the bath and banks easily accessible to the skimmer. Thus, an ordinary Heroult furnace may have side walls built somewhat similar to those shown at *a* in the accompanying sketch (Fig. 1). It is readily seen that the little bay formed between charging door and spout is almost inaccessible to the skimmer, and little shelflike crusts of slag are liable to remain in this relatively cool part of the furnace, submerged slightly in the metal, with disastrous results to the final analysis. Proper attention to banking up the side walls with granular fettling may bring them out to the line shown at *b*, but normally the best that can be continually maintained in commercial practice would be some intermediate and rather unsatisfactory mean position such as *c*.

Desulphurization

After the skimming operation, which requires about 15 min., the doors are opened long enough to charge in a few shovelfuls of ingredients for the carbide slag. This is composed primarily of lime, fluorspar and crushed coke, with a little washed silica sand (free from alumina) added to intensify the deoxidation necessary to the proper desulphurizing action of carbide. Desulphurization requires between 60 and 90 min. at a very high temperature. After charging and superheating this slag, the current is reduced to about 80 per cent of maximum input, so that the arc may disturb the

bath as little as possible, since the desulphurizing slags act best after rabbling in, under quiescent mass conditions.

As before, the best quick indication of the desulphurization progress is had by eye examination of slag tests—a proper slag should be pure white above gray, and the quenched piece should give a clear odor of acetylene, indicating the presence of carbide. Such slags need constant attention, building them up as necessary by further additions of their ingredients. Little if any of the pulverized coke enters the metal bath as such to influence its carbon content, since it floats on top the slag layer and continually forms the calcium carbide required for desulphurization.

During this stage the metal is sampled at short intervals and a series of chemical analyses indicate the course of the carbon and manganese elimination. Preliminary nickel assays are also made, although little trouble is experienced with this element—practically 100 per cent recovery of the metal charged at any stage is had. Indeed, it may be remarked in passing that alloying elements (other than deoxidizers and scavengers) may be recovered almost quantitatively by proper attention to melting practice and by protecting with high-lime slags. Even tungsten can be retained in remelting tool scrap if high temperatures are used. An exception to this statement is chromium, which slags readily. Of course, a large loss in manganese is to be expected—only about one-half of that added as ferro remains in the metal.

When desulphurization has proceeded well toward completion (final metal should contain but 0.015 to 0.020 per cent), the proper ferros are added to produce a correct alloy, and very hot metal quickly poured, allowed to stand in the ladle only long enough for the slag to liquate, and then poured into ingot molds. The ingots themselves are 8 in. by 14 in. in cross-section, and are cast in metal molds, split longitudinally and with the usual side lugs for clamping the halves together. A short rectangular sinkhead is placed on the mold, which is top-poured in about 50 seconds. As soon as a sufficiently strong skin has chilled on the hot ingot the molds are opened so that during subsequent cooling there may be no strains in the ingot from the shrinkage in length, top to bottom.

The teeming ladle retains no skull of any sort, a characteristic of hot electric-furnace metal, quickly cast. This is one of the main points of difference in open-hearth and electric steel—the former requires a fairly high silicon (0.20 to 0.35 per cent) to quiet the metal over a slow pouring period. Electric steel should be quiet in the furnace before tapping; silicon in it at 0.06 to 0.07 produces metal with higher physical characteristics than at the open-hearth minimum, and even this low amount is only used to produce a homogeneous metal by reducing a tendency toward segregation.

After pouring the bath, the furnace doors are opened and the lining repaired by fettling through the side doors. For this work a patented refractory—double calcined dolomite sold under various trade names—gives good satisfaction. It is banked up against the side walls in the ordinary manner, an especially large amount being required at the rear wall around No. 1 electrode, the hottest part of the furnace.

One may here remark about the present exorbitant cost of refractories in the making of highest grade electric steels. Whereas the refractory cost early in 1917 amounted to about $1.25 per ton, late in 1918, by the combined action of increase in price and decrease in quality, the cost had jumped to $5.50. Electric-furnace men will therefore naturally welcome a return to pre-war conditions among the refractory makers.

Technical and trade literature often bears the statement that electric steel of the nature described in this article can be marketed in commercial quantities at a small differential over open-hearth. This is not true. The differential required today is no less than $25 per ton. With the stabilization of public service electrical supply and other industrial conditions, this spread will be narrowed, but at present even a greater increase in price is needed and is actually justified by the improved service of electric over open-hearth steel. This will become increasingly apparent as engineers fix their minds upon cost per year or cost per unit of service rather than upon first cost.

To recapitulate, the time required for one heat may be tabulated approximately as:

Charging	45 min.
Melting	2 hr. 45 min.
Dephosphoring	45 min.
Skimming	15 min.
Desulphurizing	1 hr. 15 min.
Pouring and fettling	15 min.
Total	6 hr.

Thus about four heats are produced from cold scrap every 24 hours at a current consumption of from 750 to 825 kw.-hr. per ton. Always bear in mind, however, that this figure is for a ton of high-grade steel poured. Common remelted steels or non-purified melts of inconstant composition take less current and give correspondingly less perfect results. The time of refining is materially increased by the necessity of making several chemical analyses during the last stages, especially if the furnace is to be caught and poured as the carbon or manganese is coming down. Otherwise the bath may be built up in the last stages to any desired composition. In this, metallurgical practice is not materially different from standardized open-hearth manipulation.

Pittsburgh, Pa.

Chemists' Club Scholarships

The announcement is made by the scholarships committee of the Chemists' Club of New York, that the Bloede and the Hoffmann scholarships will be awarded for the academic year 1919-1920. These scholarships were founded by Dr. Victor G. Bloede of Baltimore, and Mr. William F. Hoffmann of Newark, with the object of giving financial assistance to deserving young men to obtain an education in the field of industrial chemistry or chemical engineering.

These scholarships will be open to properly qualified applicants without restriction as to residence, and may be effective at any institution in the United States designated or approved by the scholarships committee.

Applicants must, as a minimum qualification, have completed a satisfactory high school training involving substantial work in elementary chemistry, physics and mathematics, and present a certificate showing that they have passed the entrance examination requirements of the college entrance examination board or its equivalent.

All inquiries should be addressed to the Scholarships Committee, Chemists' Club, 52 E. 41st St., N. Y.

Nodulizing Flotation Concentrates in a Rotary Kiln With Powdered Coal

BY ROBERT M. DRAPER

THE rotary kiln has long been used in the cement industry, but only recently has it been utilized in the metallurgy of copper.

In September, 1912, a small 60-ft. kiln was installed at the plant of the United States Metals Refining Co. at Chrome, N. J., for the purpose of nodulizing a large accumulation of flue dust. The kiln proved a success from the start, and after the accumulated flue dust was used up, flotation concentrates were nodulized into a very satisfactory blast-furnace product. Several years later kilns were installed at Braden and operated very successfully on flotation concentrates. Both of these installations used fuel oil and at the time considerable doubt was expressed whether the operation would be successful with powdered coal on account of the low temperature required.

In 1917 the Canada Copper Corporation, Ltd., in developing its large low grade copper property at Copper Mountain, British Columbia, found that it was going to have a large amount of high grade flotation concentrates to sell and came to the conclusion that perhaps nodulizing would be of advantage. Oil for fuel was out of the question, and as there was a cement kiln in the vicinity of the mine with all the facilities for pulverizing the coal, it was decided to try some experiments with this equipment.

TWO MAIN PROBLEMS

There were two main problems: First, to put the flotation concentrates in shape physically for the blast-furnace and second, to retain as much of the sulphur as possible. The kiln used was the usual type in cement practice, 125 ft. long and 7 ft. diameter inside of the brick work, and was in very good shape. The coal dust machinery was designed to furnish a much larger volume than was necessary for nodulizing flotation concentrates, but could be regulated fairly satisfactorily by means of a slide in the discharge pipe.

The method in use for feeding the concentrates into the kiln at Chrome had been by a screw conveyor, but this had not proved entirely satisfactory owing to choking the conveyor, and we decided to try hoisting the concentrates up to the feed end of the kiln by a bucket elevator and chuting them down into the kiln through a pipe. Owing to the original design of the plant a slope of 60 deg. was all that could be obtained for this pipe and we had more or less trouble with choking. It required a man constantly to poke the concentrates down the pipe, while the bucket elevator also gave trouble with choking.

THREE FLOTATION CONCENTRATES USED

For the experiments three different kinds of flotation concentrates were used: Highland Valley flotation concentrates, Highland Valley table concentrates, and Copper Mountain concentrates. Assays were as follows:

	Cu	SiO_2	Fe	CaO	S
Highland Valley flotation concentrates	19.25	19.2	18.7	2.0	18.0
Highland Valley table concentrates....	21.65	19.0	25.1	1.7	19.0
Copper Mountain concentrates.......	26.57	20.0	15.8	3.9	18.7

The copper was present in all three ores principally as bornite and chalcopyrite.

To retain as large a percentage of sulphur as possible several different schemes were tried. A spray pipe was run down into the feed end of the kiln for a distance of 6 ft. and a spray of water used to keep the concentrates as wet as possible so they would not have a chance to roast before reaching the nodulizing zone. The discharge end of the kiln was kept as nearly hermetically sealed as possible to prevent the entrance of air, but it was found extremely difficult to obtain this condition. A damper was placed in the stack and kept open just sufficiently to permit the gases to escape while keeping the kiln full of the fumes from the concentrates at all times. We found no trouble in regulating this damper so that a small amount of fume backed out of the feed end of the kiln at all times but at no time in sufficient quantity as to be obnoxious.

BEST METHOD NOT DETERMINED

The amount of material to experiment with was not sufficient to determine which of these methods was the most satisfactory, but I am inclined to believe the damper in the stack is much the more efficient, as there can be very little tendency to draw air into a kiln that is so choked that fumes back up at both ends. Hermetically sealing the discharge end would of course give the same result, but this is very hard to do in actual practice.

How much good the spray pipe at the feed end accomplished I do not know, but I believe it would have an important bearing in reducing the dust losses.

No trouble was experienced from the start in making a very satisfactory nodule from a physical standpoint, the majority varying from ¼ to ½ in. in diameter, and hard enough to withstand quite a sharp blow with the hammer.

ANALYSIS OF SAMPLES

Careful samples of all tests were taken and sent to the smelter at Greenwood for analysis. These samples showed that we were retaining 70 to 80 per cent of the original sulphur. In one case when the nodules were giving off dense fumes of sulphur as they were discharged from the kiln the sample was split and half allowed to cool slowly in the air and half plunged immediately into water. The sample that was air cooled showed practically as much sulphur as that cooled in the water. This fact is important, as the nodules show a decided tendency to break up if cooled with water, but they could be readily cooled by passing them along a revolving cylinder.

The coal used was from mines in the vicinity—a rather poor bituminous coal carrying 20 per cent ash. No trouble was experienced in keeping the coal ignited, in fact several times after an hour's shut-down the coal was turned on and ignited without extra fuel of any sort.

We found no difficulty in nodulizing five tons of concentrates per hour with a coal ratio of 1 to 15.

The action all the way through was very similar to nodulizing with fuel oil. No trouble was experienced from the formation of accretions upon the walls of the kiln, and those that did form were within 12 or 15 ft. of the discharge end of the kiln, where they could be easily reached and barred off. There did not seem to be any excessive dust losses. Only 2 per cent of the amount fed settled in the chamber at the base of the stack, and the stack itself at no time gave any indications of excessive losses. There is no doubt in my mind that nodulizing in the rotary kiln with powdered coal will be as successful as in installations using fuel oil.

Southboro, Mass.

Notes on the Influence of Certain Variables Associated With the Anneal of Cold-Worked Alpha Brass

Degree of Plastic Deformation—Temperature and Time of Anneal—Rate of Heating Through the Germinative Temperature—Size and Uniformity of the Grains Prior to the Plastic Deformation—Potential Possibilities of Rolled Metal

BY ARTHUR PHILLIPS* AND GEORGE C. GERNER*

ONE of the first papers[1] to deal with the characteristics of recrystallization and grain growth of cold-worked alpha brass on annealing pointed out that different degrees of plastic deformation materially affected the initial temperature of visible recrystallization and also the size of the recrystallized grains. Later writers, notably Jeffries[2] and Howe[3], in discussing this paper, have presented what seem to be the main factors having a controlling influence over the mechanism of recrystallization and grain growth of pure metals and solid solutions.

It may not be out of place to review briefly the principal variables which have a pronounced effect on the mechanical properties and microstructure of commercial alpha brass on anneal subsequent to cold-reduction.

1. Degree of Plastic Deformation

In a paper[4] previously mentioned, it has been shown that different degrees of plastic deformation have a very decided influence on the temperature of recrystallization. In general, other conditions being the same, the greater the cold-reduction the lower the temperature of visible recrystallization. As evidence of this, the authors found that an anneal between 275 and 300 deg. (30 min.) following a reduction of 40 per cent sufficed to cause incipient recrystallization; the same brass reduced only 4 per cent required an anneal at 650 deg. to produce positive structural evidence of re-orientation. Furthermore, the size of the recrystallized units decreased progressively with increase in the degree of plastic deformation. Bassett and Davis, in a recent paper[5] showing the relation between the grain size and Brinell hardness of cartridge brass, have also shown that the grain size of brasses annealed at the lower temperatures is greatly affected by the degree of reduction.

2. Temperature and Time of Anneal

As stated in the preceding paragraph, the temperature of recrystallization of brass may extend over a very considerable temperature range depending upon the degree of deformation to which the metal has been subjected. Characteristic curves showing the grain size and mechanical properties as a function of the temperature (for a given reduction and constant period of anneal) show how necessary it is, from the practical standpoint, to give careful attention to the annealing temperature if specific properties are desired.

With regard to the effect of time of anneal, it is a matter of general knowledge that in the case of rather severely worked brass, i.e., corresponding to an ordinary mill reduction, the time factor is of great importance when the annealing temperature is within the range of incipient recrystallization. For higher temperatures, when approximate equilibrium conditions are rapidly attained, the question of time, between rather broad limits, is of less importance. Although this is, perhaps, a matter of common knowledge, it seems desirable to include in this paper experimental data which show the effect of time of anneal at 650 deg. on the tensile strength of alpha brass having various reductions. It is to be understood, however, that the experimental data have simply been taken bodily from the results of an investigation carried on with another objective in view. For this reason, we ask indulgence for one or two features connected with the experimental procedure which do not seem to be consistent with the subject under consideration.

For the experiments we selected from the same coil several strips of cartridge brass†, 4 in. wide and 0.185 in. thick, which had been given a uniform reduction of 43 per cent by cold-rolling in the mill. The strips were annealed together in an American gas furnace at 700 deg. for one-half hour, with a preheating period of 10 minutes. The temperature data were obtained by means of a carefully calibrated base-metal pyrometer.

Following this laboratory anneal, four strips were given mill reductions of 6.6, 15, 25 and 40 per cent respectively. Six test pieces, 8 in. by 1 in., were cut from each strip and the twenty-four bars were divided into six sets of four pieces; each set representing reductions from 6.6 to 40 per cent. The total charge was then placed in a rectangular muffle, wound with nichrome ribbon, and annealed at 650 deg. Temperature measurements were made by means of a platinum-rhodium couple, inserted in a hole drilled into the end of one strip, used in conjunction with high-resistance galvanometer. The long preheating period, 1 hr. and 7 min., was due to the mass of metal in the furnace.

A set of test bars was removed at successive intervals in the following order: end of preheating period (i.e., 1 hr., 7 min.), 15 min., 30 min., 1 hr., 2 hr. and 5 hr. After carefully milling the bars to a width of 0.50 in. over a gage length of 3 in., they were tested in a 50,000-lb. Riehle universal testing machine. The

*Metallurgical Department, Bridgeport Brass Co.

[1]Mathewson & Phillips: "The Recrystallization of Cold-Worked Alpha Brass on Annealing," *Trans.*, Amer. Inst. Min. Eng., 1916, Vol. 54, p. 608.

[2]Jeffries: Discussion of above paper, p. 658.

Jeffries: "Grain Growth Phenomena in Metals," *Trans.*, Amer. Inst. Min. Eng., 1916, Vol. 56, p. 571.

[3]Howe: "Recrystallization After Plastic Deformation," *Trans.*, Amer. Inst. Min. Eng., 1916, Vol. 56, p. 561.

Howe: "On Grain Growth," *Trans.*, Amer. Inst. Min. Eng., 1916, Vol. 56, p. 583.

[4]Mathewson & Phillips, *loc. cit.*

[5]Bassett and Davis: "A Comparison of Grain-size Measurements and Brinell Hardness of Cartridge Brass," *Trans.*, Amer. Inst. Min. Eng., February meeting, 1919.

†Analysis: Copper, 70.24; iron, 0.023; lead, 0.014 per cent.

testing data are tabulated in Table I and plotted in Fig. 1. Although we were unable to make these tests in duplicate, due to limited furnace capacity, we believe that the results are fairly reliable and significant. Samples for microscopic examination were retained, but, unfortunately, the reproduction and discussion of the micrographs is not possible in this paper.

A study of these data seems to indicate that at 650 deg. a measurable length of time is necessary to produce apparent equilibrium values for all reductions investigated. In the case of the brass reduced 40 per cent, continued annealing up to 2 hr. was attended with lower tensile strength. Since the value of the tensile strength after a 2-hr. anneal is practically identical with that found after a 5-hr. anneal, it seems reasonable to conclude that, from the practical standpoint, approximate equilibrium conditions are obtained after the shorter period. A repetition of this work will, of course, be necessary before final conclusions can be drawn regarding the effect of time of anneal on the mechanical properties of rolled brass. For this reason we do not think it advisable to enter into a lengthy discussion of the magnitudes involved, but simply offer the testing data for their possible suggestive value.

TABLE I—EFFECT OF TIME OF ANNEAL (AT 650 DEG. C.) ON TENSILE STRENGTH OF COLD-WORKED ALPHA BRASS

Per Cent Reduction	Time at Annealing Temperature	Original Size Dimensions, Inches	Original Size Area, Sq.In.	Breaking Weight	Tensile Strength, Lb.Sq.In.
6.6	Unannealed	0.168x0.755	0.1270	6000	47,300
15.5	Unannealed	0.152x0.744	0.1131	5980	53,000
25.0	Unannealed	0.136x0.750	0.1020	6120	60,000
40.0	Unannealed	0.108x0.753	0.0813	6000	73,800
6.6	0	0.503x0.168	0.0845	3850	45,600
6.6	15 minutes	0.500x0.166	0.0830	3790	45,700
6.6	30 minutes	0.499x0.168	0.0838	3790	45,250
6.6	1 hour	0.497x0.167	0.0830	3780	45,600
6.6	2 hours	0.471x0.168	0.0792	3560	45,000
6.6	5 hours	0.487x0.167	0.0813	3650	44,900
15.5	0	0.503x0.150	0.0754	3560	47,200
15.5	15 minutes	0.503x0.150	0.0754	3510	46,500
15.5	30 minutes	0.509x0.150	0.0764	3550	46,500
15.5	1 hour	0.502x0.151	0.0757	3520	46,450
15.5	2 hours	0.508x0.151	0.0767	3550	46,300
15.5	5 hours	0.507x0.151	0.0765	3500	45,750
25.0	0	0.500x0.132	0.0660	3150	47,750
25.0	15 minutes	0.503x0.133	0.0669	3140	46,950
25.0	30 minutes	0.500x0.132	0.0660	3100	47,000
25.0	1 hour	0.498x0.133	0.0662	3070	46,400
25.0	2 hours	0.506x0.132	0.0668	3100	46,400
25.0	5 hours	0.496x0.133	0.0660	3020	45,800
40.0	0	0.471x0.107	0.0503	2410	47,850
40.0	15 minutes	0.498x0.108	0.0538	2540	47,250
40.0	30 minutes	0.494x0.108	0.0533	2490	46,700
40.0	1 hour	0.490x0.107	0.0524	2410	46,000
40.0	2 hours	0.473x0.107	0.0506	2310	45,650
40.0	5 hours	0.491x0.107	0.0525	2400	45,700

3. Rate of Heating Through the Germinative Temperature

Jeffries[6] has shown that in the case of pure metals and solid solutions reduced at least 15 per cent by cold-work, the grain size equilibrium (for any temperature above the equiaxing range) depends largely on the rate at which the metal passes through the equiaxing range. In general, the faster the metal is heated through this range the smaller will be the equilibrium grain size; conversely, the greater the lag in passing through the equiaxing temperature the greater the equilibrium grain size. Grain size equilibrium is defined by Jeffries as "the point where grain size either changes none or slowly." In other words, there is a small temperature range, i.e., the "germinative temperature," for every reduction at which grain growth is particularly marked. The period during which the metal is at the "germinative temperature," as remarked above, is an important factor regulating the early stages of grain growth. Although the rate of heating, in the case of alpha brass, may, under special and exceptional conditions, have an important effect on its structure and properties, yet in ordinary mill practice, which generally involves a moderately high temperature of anneal following a rather high degree of plastic deformation, considerable latitude may be allowed in the rate of heating without materially affecting the characteristics of the anneal.

[6]Jeffries: Amer. Inst. Min. Eng., 1916, Vol. 54, p. 660.

4. Size and Uniformity of the Grains Prior to the Plastic Deformation

Jeffries[7] remarks in this connection that "in a given pure metal with a given amount of cold deformation, the grain size before deformation will have a marked effect on the selective grain growth during anneal. If the initial grain size is large, the grain fragments formed during annealing will be correspondingly large, and if the initial grain size is small the grain fragments will also be smaller than in the previous case." Also, "when the total average cold deformation exceeds 30 to 40 per cent reduction in area of the metal, the number of germinative grains formed during normal muffle heating may approximately equal the number of equilibrium grains for the maximum temperature reached during annealing, and thus the metal is said to be fine grained." On the other hand, if the cold deformation is comparatively slight, the local strain gradients resulting produce comparatively few germinative grains which, during the

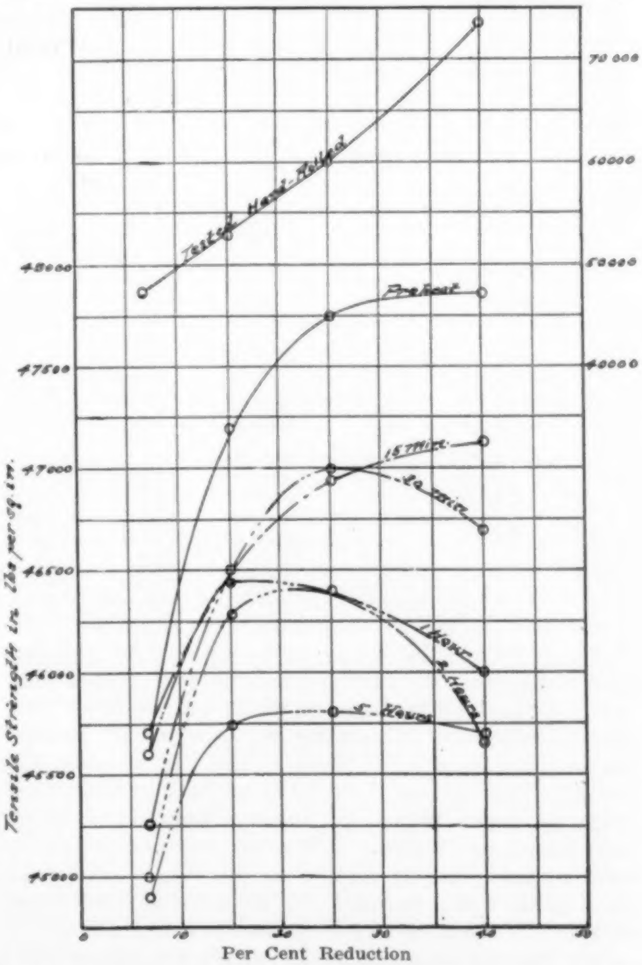


FIG. 1. EFFECT OF TIME OF ANNEAL (650 DEG. C.) ON TENSILE STRENGTH OF COLD-WORKED ALPHA BRASS

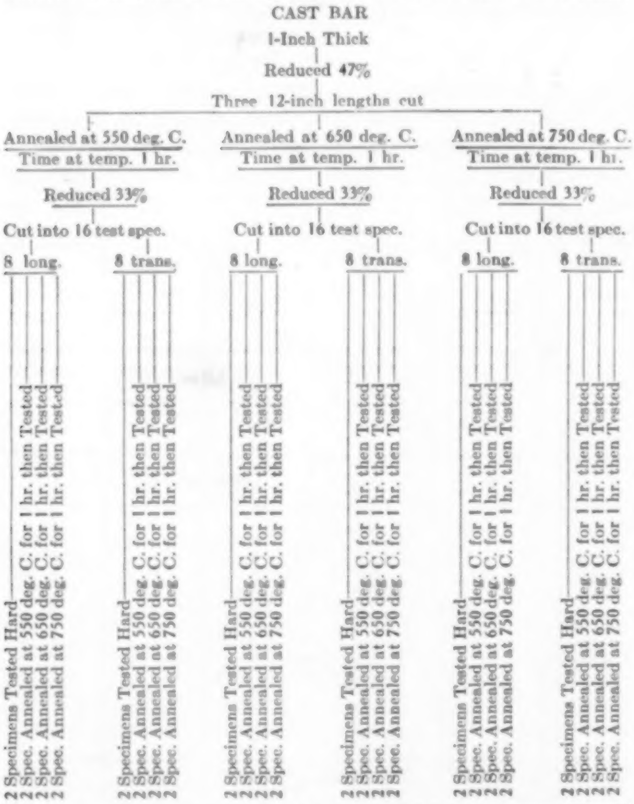
[7]Jeffries: Amer. Inst. Min. Eng., 1916, Vol. 56, p. 575.

subsequent anneal, attack and absorb the inert grains. Such treatment tends to favor "selective grain growth" and is characterized by coarse crystallization.

In order to learn the influence of the grain size prior to the plastic deformation on the microstructure and mechanical properties of rather severely worked alpha brass annealed under conditions comparable to mill practice, the following experimental work was undertaken. It should be noted that the reduction given the metal used in this investigation exceeded the minimum value (i.e., 30 per cent) mentioned by Jeffries.

The accompanying diagram shows the treatment given each test specimen, starting from the cast bar‡

DIAGRAM SHOWING TREATMENT GIVEN EACH TEST SPECIMEN



(1.0 in. thick) to the testing of the pieces. As indicated by the diagram, the cast bar was reduced 47 per cent, cut in 12-in. lengths, three of which were used for this experimental work. One piece was annealed at 550 deg., another at 650, and the third at 750. In all cases the period of anneal was 1 hr.; the preheat period varied from 15 to 40 min. All anneals were made in an American gas furnace. After the anneals the strips were reduced 33 per cent by cold-rolling in the mill. Each piece was then cut into sixteen test specimens, eight in the direction of rolling and eight at right angles to the direction of rolling. This gave six lots of samples, eight in each lot. All strips were milled so as to give a test section 4½ in. long, with a cross-sectional area 0.625 in. times the thickness of the metal (0.355 in.).

Each lot was again divided into four sets, two to a set. One set from each lot was tested hard; the remaining three sets were annealed for 1 hour at 550, 650 and 750 deg. respectively. A piece for microscopic examination was cut from the end of each test piece.

‡Analysis: Copper, 70.38; iron, 0.018; lead, 0.005 per cent.

Tensile and hardness tests were made on each specimen. The scleroscopic tests were made with a Shore instrument; an Olsen (hydraulic type) machine was used in determining the Brinell hardness. Two indentations were made on each test piece, one at each end, and the average value given. The indentations on the unannealed test pieces were, of course, elliptical. For this

TABLE II—EFFECT OF GRAIN SIZE PRIOR TO PLASTIC DEFORMATION ON TENSILE PROPERTIES OF ANNEALED ALPHA BRASS

(Longitudinal Tests)

Temp. of Final Anneal	Tensile Strength Lb. Per Sq.In.	Per Cent. Elong. in 2 in.	Per Cent Red. Area	Hardness Brinell No.	Hardness Scler. No.	Grains Per Sq.In. at 50×
Annealed at 550 deg. C. before last reduction.						
Unannealed	75,400	18.5	51.7	143	33–35	.....
Unannealed	75,900	18.0	51.9	143	33–35	.....
Average	75,650	18.25	51.8	143	34	.....
550 deg. C.	48,300	69.0	70.8	63	11–12	.....
550 deg. C.	50,100	66.0	67.0	63	11–12	169.0
Average	49,200	67.5	68.9	63	11.5	.....
650 deg. C.	45,950	69.0	72.6	54	10	.....
650 deg. C.	47,600	72.0	70.3	54	10	.....
Average	46,780	70.5	71.4	54	10	57.8
750 deg. C.	43,450	77.5	67.5	45	8	.....
750 deg. C.	43,820	76.0	64.9	45	8	.....
Average	43,640	76.8	66.2	45	8	13.2
Annealed at 650 deg. C. before last reduction						
Unannealed	74,800	19.0	53.2	143	33–35	.....
Unannealed	74,900	17.0	56.8	143	33–34	.....
Average	74,850	18.0	55.0	143	34	.....
550 deg. C.	48,400	72.0	73.5	57	11	.....
550 deg. C.	47,700	70.0	74.0	59	11	.....
Average	48,050	71.0	73.75	58	11	89.0
650 deg. C.	45,620	75.0	74.4	50	10	.....
650 deg. C.	44,650	73.0	74.8	52	10	.....
Average	45,850	74.0	74.6	51	10	36.0
750 deg. C.	42,650	80.0	70.2	43	8	.....
750 deg. C.	43,180	80.5	69.4	45	8	.....
Average	42,900	80.3	69.8	44	8	8.5
Annealed at 750 deg. C. before last reduction						
Unannealed	68,800	24.0	50.2	136	31	.....
Unannealed	67,100	24.0	52.8	130	30	.....
Average	67,950	24.0	51.5	133	30.5	.....
550 deg. C.	47,150	73.0	71.9	57	11	.....
550 deg. C.	47,200	75.0	75.6	57	11	.....
Average	47,175	74.0	73.7	57	11	45.0
650 deg. C.	47,700	77.5	68.7	50	10	.....
650 deg. C.	44,200	80.5	74.3	50	10	.....
Average	44,200	79.0	71.5	50	10	21.5
750 deg. C.	42,100	85.0	70.1	44	8	.....
750 deg. C.	42,280	89.0	70.7	43	8	.....
Average	42,190	87.0	70.4	43.5	8	3.6

TABLE III—EFFECT OF GRAIN SIZE PRIOR TO PLASTIC DEFORMATION ON TENSILE PROPERTIES OF ANNEALED ALPHA BRASS

(Transverse Tests)

Temp. of Final Anneal	Tensile Strength Lb. Per Sq.In.	Per Cent Elong. in 2 In.	Per Cent Red. Area	Hardness Brinell No.	Hardness Scler. No.	Grains. Per Sq.In. at 50×
Annealed at 550 deg. C. before last reduction						
Unannealed	77,800	11.0	27.8	158	33–35	.....
Unannealed	78,200	12.0	21.7	158	33–35	.....
Average	78,000	11.5	25.1	158	34	.....
550 deg. C.	49,900	66.0	58.7	63	12	.....
550 deg. C.	49,300	62.0	60.0	63	11	.....
Average	49,600	64.0	59.3	63	11.5	169.0
650 deg. C.	45,900	71.0	66.3	54	10	.....
650 deg. C.	45,900	71.0	61.5	54	10	.....
Average	45,900	71.0	63.9	54	10	57.8
750 deg. C.	43,050	76.0	62.4	45	8	.....
750 deg. C.	42,620	77.5	65.7	45	8	.....
Average	42,800	76.8	64.0	45	8	13.2
Annealed at 650 deg. C. before last reduction						
Unannealed	75,200	13.0	32.2	158	33–34	.....
Unannealed	75,400	9.0	27.8	158	34–35	.....
Average	75,300	11.0	30.0	158	34	.....
550 deg. C.	47,300	66.0	50.2	57	10	.....
550 deg. C.	48,900	69.0	50.3	59	10	.....
Average	48,050	67.5	50.25	58	10	89.0
650 deg. C.	45,200	73.0	69.5	50	10	.....
650 deg. C.	45,500	76.0	71.4	50	9–10	.....
Average	45,350	74.5	70.4	50	10	36.0
750 deg. C.	42,280	80.0	69.4	45	8	.....
750 deg. C.	Flaw in sample			44	8	.....
Average	42,280	80.0	69.4	44.5	8	8.5
Annealed at 750 deg. C. before last reduction						
Unannealed	68,100	15.0	28.7	143	30	.....
Unannealed	68,300	9.0	22.2	143	31	.....
Average	68,200	12.0	25.45	143	30.5	.....
550 deg. C.	46,700	68.5	70.7	57	11	.....
550 deg. C.	46,600	69.0	62.7	57	11	.....
Average	46,650	68.75	66.2	57	11	45.0
650 deg. C.	43,200	79.0	73.4	50	10	.....
650 deg. C.	43,820	79.5	71.1	50	10	.....
Average	43,500	79.3	72.2	50	10	21.5
750 deg. C.	Flaw in sample			44	8	.....
750 deg. C.	42,650	82.0	66.5	44	8	.....
Average	42,650	82.0	66.5	44	8	3.6

reason, the axis parallel to the direction of rolling was measured on the longitudinal test pieces; the axis normal to the direction of rolling was measured on the transverse pieces. Tensile tests were made on a 50,000-lb. Riehle universal testing machine. In addition to the tensile strength determinations, values for the per cent elongation and per cent reduction in area were obtained.

Results of the Tests

Table II shows the results of tests made on specimens taken in the direction of rolling; Figs. 2 and 3 present the same data in plotted form. Table III gives the results of tests made on test pieces taken normal to the direction of rolling. As the transverse tests of the annealed samples agreed so closely with the values obtained on the longitudinal tests, it did not seem necessary to plot the results shown in Table III. The average values obtained on the unannealed test pieces, longitudinal and transverse, are given again in Table IV in order that they may be readily compared. It will be noted in Figs. 2 and 3 that the curves show the physical properties as a function of the anneal before the final reduction, instead of the final anneal as is the common practice.

TABLE IV—DIRECTIONAL PROPERTIES OF ALPHA BRASS REDUCED 33 PER CENT BY COLD ROLLING SUBSEQUENT TO ANNEAL AT 550, 650 AND 750 DEG. C., RESPECTIVELY

Temperature of Anneal, Deg. C.	Tensile Strength, Lb. Sq.In.	Per Cent Elongation in 2 In.	Per Cent Reduction of Area
550 Longitudinal	75,650	18.25	51.8
550 Transverse	78,000	11.5	25.1
650 Longitudinal	74,850	18.0	52.6
650 Transverse	75,300	11.0	30.0
750 Longitudinal	67,950	24.0	52.1
750 Transverse	68,200	12.0	25.5

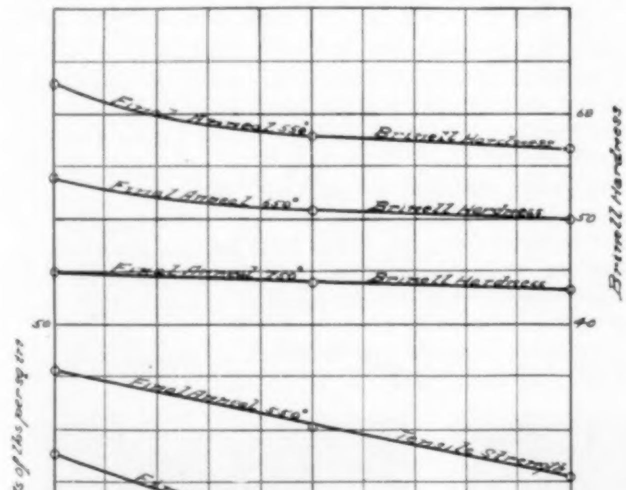


FIG. 2. EFFECT OF GRAIN SIZE PRIOR TO COLD-REDUCTION ON TENSILE PROPERTIES OF ANNEALED ALPHA BRASS (LONGITUDINAL TESTS)

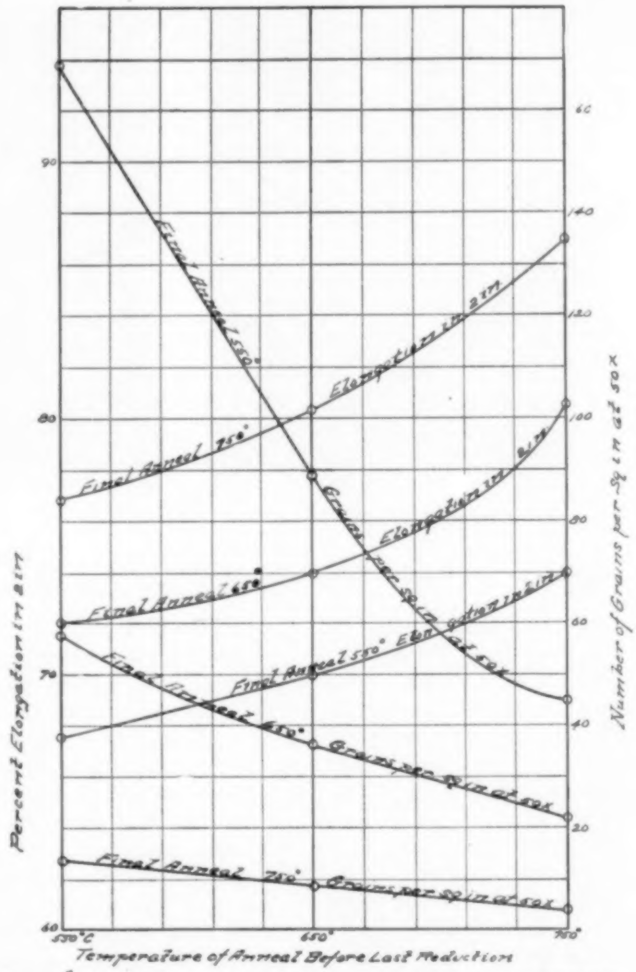


FIG. 3. EFFECT OF GRAIN SIZE PRIOR TO COLD-REDUCTION ON TENSILE PROPERTIES OF ANNEALED ALPHA BRASS (LONGITUDINAL TESTS)

Twelve micrographs, showing the effect of the grain size before plastic deformation on the structure produced by the final anneal, are shown in Plates I, II, III and IV. Grain size measurements (expressed in grains per sq.in. at 50 diameters) are given in Tables II and III and are plotted in Fig. 3.

TABLE V—DIRECTIONAL PROPERTIES OF ALPHA BRASS REDUCED 33 PER CENT BY COLD-ROLLING SUBSEQUENT TO ANNEAL AT 680 DEG. C.

	Original Size					
	Dimensions, Inches	Area, Sq.In.	Breaking Weight, Lb.	Thesile Strength, Lb. Sq.In.	Per Cent Elong. in 2 In.	Per Cent Reduction of Area
Longitudinal test bar...	0.610x0.354	0.2159	15,230	70,500	20.0	51.7
Longitudinal test bar...	0.607x0.353	0.2142	15,050	70,300	18.5	49.2
Longitudinal test bar...	0.606x0.352	0.2133	15,050	70,600	19.0	52.9
Average............	....	......	......	70,470	19.2	51.3
Transverse test bar....	0.643x0.355	0.2282	16,140	70,700	15.5	35.4
Transverse test bar....	0.620x0.355	0.2200	15,570	70,750	11.0	31.6
Transverse test bar....	0.624x0.355	0.2215	15,620	70,500	12.0	31.7
Average............	....	......	.....	70,650	12.8	32.9

Tensile tests on the annealed samples indicate that while the grain size before the final reduction has some influence on the mechanical properties of the annealed brass, the magnitude of the effect is small, especially in metal annealed at the higher temperatures. It will be

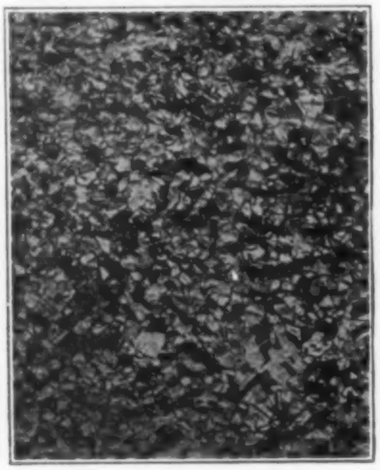


Fig. A. One hour at 550 deg. C.

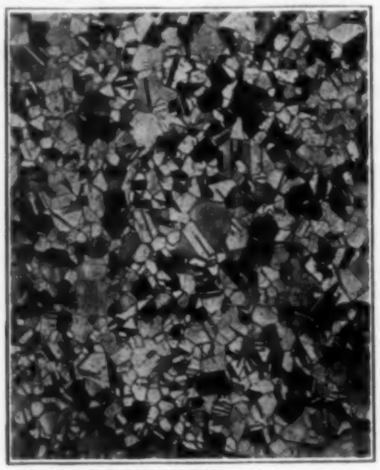


Fig. B. One hour at 650 deg. C.

Fig. C. One hour at 750 deg. C.

PLATE I

Cartridge brass (copper, 70.33; lead, 0.005; iron, 0.018 per cent). Effect of anneal after 47 per cent reduction by rolling. Etched with ammonia and hydrogen peroxide. × 50.

seen from Fig. 2 that the tensile strength curve for 750 deg. final anneal is almost horizontal, indicating that for this anneal the tensile strength is, within certain limits, independent of the previous grain size. The Brinell hardness curve of Fig. 2 and the crystal count curve of Fig. 3 for the same anneal also show very little change, but the curve for per cent elongation in Fig. 3 slopes upward, which seems to indicate that large initial grain size tends to increase the elongation. The same relation seems to hold for the lower temperature final anneals as indicated by the elongation curves of Fig. 3, all of which show about the same slope. In the lower temperature anneals, the smaller initial grain size seems to yield finer grain fragments upon subsequent anneal, as is shown by the crystal count curves in Fig. 3. The tensile strength is also increased as would be expected from the finer grain produced by the anneal.

An examination of the micrographs shown in Plates I, II, III and IV seems to indicate that the grain size prior to reduction is one of the important factors affecting the final grain size. The samples annealed at the higher temperatures show considerable variation in grain size within the individual specimens. This type of structure, as shown by Fig. C, Plate III, and Figs. A, B and C, Plate IV, is quite characteristic of commercial brass. In view of the difficulty of obtaining grain counts with a high degree of accuracy, it does not seem advisable to subject the grain count curves of Fig. 3 to critical analysis. It is evident, however, that in all cases the grain size after all final anneals (i.e., 550, 650, 750 deg.) increased progressively with increase in temperature of the anneal prior to the reduction.

Ductility

As has been previously stated, the annealed brass when tested longitudinally and transversely showed no directional properties; the rolled metal, however, when tested showed that the longitudinal test pieces yielded the higher values of ductility. These values are given in Table IV, from which it will be seen that although the tensile strength is practically the same, there is a very marked difference in the per cent elongation and the reduction of area. The tests become especially intresting when compared with the values given by Price and Davidson[9] for similar tests on common high brass

[9]Price and Davidson: "Physical Tests on Common High Brass Taken Parallel and at Right Angles to the Direction of Rolling" Amer. Inst. Metals, 1916, Vol. 10, p. 133.

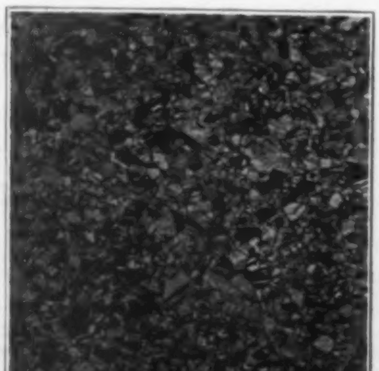


Fig. A. One hour at 550 deg. C.

Fig. B. One hour at 550 deg. C.

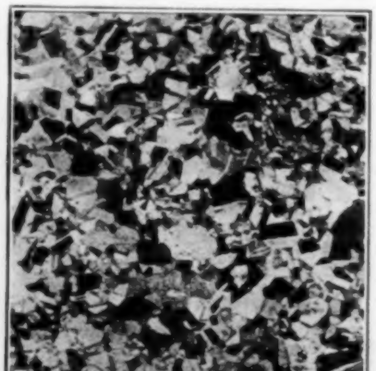


Fig. C. One hour at 550 deg. C.

PLATE II

Cartridge brass (copper, 70.33; lead, 0.005; iron, 0.018 per cent). Effect of anneal after 33 per cent reduction by rolling. Etched with ammonia and hydrogen peroxide. × 50.

Fig. A. One hour at 650 deg. C.

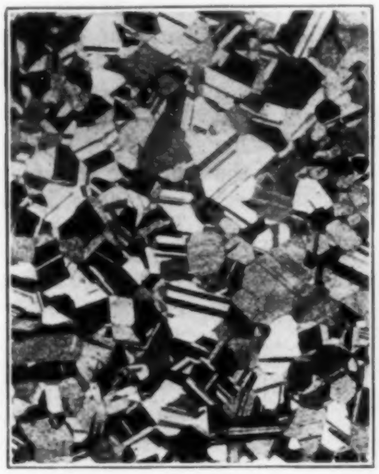


Fig. B. One hour at 650 deg. C.

Fig. C. One hour at 650 deg. C.

PLATE III

Cartridge brass (copper, 70.33; lead, 0.005; iron, 0.018 per cent). Effect of anneal after 33 per cent reduction by rolling. Etched with ammonia and hydrogen peroxide. × 50.

which had received approximately the same reduction. In this connection they state that "up to 35 per cent reduction by rolling the elongations for both kinds of strips are practically identical. But from there on the transverse specimens show marked superiority."

Since our results were contradictory to this conclusion we annealed another piece of the same bar at 680 deg. and gave it the same reduction, i.e., 33 per cent, after which three longitudinal and three transverse tests were made. The results of these tests are given complete in Table V, and it will be seen that here again the elongation and reduction of area are higher for the longitudinal samples than for the transverse. Although Price and Davidson found no difference at 33 per cent reduction, they found that the elongation was less in longitudinal than in transverse tests in the samples which had been reduced above 35 per cent. This is not in agreement with our results.

Possibly the following explanation may account for the higher ductility of the longitudinal test pieces. Due to the compressive action of the rolls, plastic deformation takes place by means of a series of slips along a large number of gliding-planes or cleavage-planes, most of which are at right angles to the direction of grain extension. The characteristic lines of deformation found in cold-worked brass are very prominent in Price and Davidson's micrographs.

In explaining their results Price and Davidson attributed the poorer ductility of the longitudinal test bars to the fact that the planes of slip (at right angles to the tensile stresses) had been utilized during the rolling operation. When making the transverse tests, however, a large number of gliding-planes would be available, since comparatively few had been utilized during the rolling operation. For this reason, they believed that the transverse test bars should give the greater elongation.

In order to explain the contrary results obtained by us, we would offer a suggestion with regard to the potential possibilities of the rolled metal. Fig. 4 (on the left) represents a test bar cut from metal at right angles to the direction of rolling. Within the individual grains, and chiefly parallel to the length of the test bar, are a very large number of lines of deformation which are indicative of plastic deformation by slip. If, as it is quite generally believed, movement by slip generates amorphous material along the gliding-planes, the test piece is reënforced by innumerable plates of amorphous

Fig. A. One hour at 750 deg. C.

Fig. B. One hour at 750 deg. C.

Fig. C. One hour at 750 deg. C.

PLATE IV

Cartridge brass (copper, 70.33; lead, 0.005; iron, 0.018 per cent). Effect of anneal after 33 per cent reduction by rolling. Etched with ammonia and hydrogen peroxide. × 50.

material of a low order of ductility. It seems reasonable to conclude, therefore, that the presence of these plates would tend to lower the ductility of the mass as a whole when subjected to a tensile force.

Fig. 4 (on the right) represents a test bar cut from the metal parallel to the direction of rolling. In this case the amorphous planes are at right angles to the length of the test section. Although slip has taken

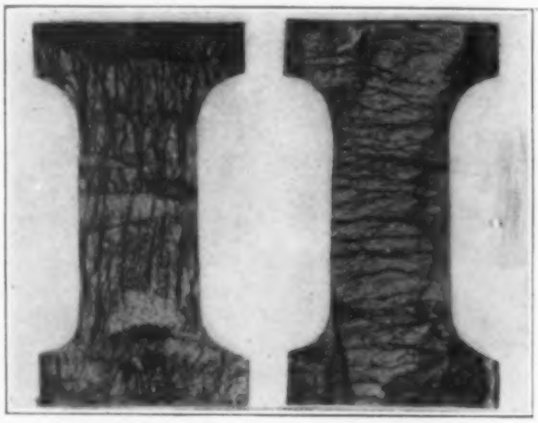


FIG. 4. TEST BAR CUT AT RIGHT ANGLES TO DIRECTION OF ROLLING (LEFT). CUT PARALLEL (RIGHT)

place along a large number of gliding-planes during the rolling operation, there must still remain a very considerable number of gliding-planes along which movement can take place when the bar is subjected to tensile test. That this is true is indicated by Price and Davidson's micrograph, Fig. D, Plate IV, showing the structure of the test piece which had been reduced approximately 80 per cent without fracture.

In other words, we believe the distribution of the amorphous material in the longitudinal test bars is more favorable to extension under tension in the transverse test bars.

In this connection the experimental results given by Price and Davidson do not seem to be at all consistent with their statement: "It is common knowledge that in a cold bend test, a piece of very hard brass can be bent several times through 180 deg. when tested longitudinally. The same specimen when bent transversely will fail before it passes through an angle of 90 deg."

Effect of Sodium Chloride on Blue-Powder Formation

BY REGINALD S. DEAN

IT IS common practice in zinc metallurgy to add small amounts of salt to the charge, which has been definitely found to reduce the amount of blue powder formed. No satisfactory explanation has been offered, however, for this action of sodium chloride, and we are therefore not in a position to develop any improvements in this method of preventing blue-powder formation.

The only text-book which discusses or even mentions the use of salt in Lodin, Metallurgie du Zinc (p. 163). The first patent granted for its use was that of Dony (French, Dec. 7, 1809), which called for a mixture of salt, chalk and potassium carbonate in the proportions of 1.4 per cent of the weight of ore NaCl, 4.1 per cent $CaCO_3$ and 0.2 per cent K_2CO_3. Later practice has reduced the proportion of salt to 1 per cent or less.

Volatilization of sodium chloride is evident from the first of the operation nearly to the end, and can be easily detected by the yellow flame. If the furnace is equipped with prolongs, a small amount of zinc chloride can frequently be found condensed in them, or if an excess of salt is added it is sometimes found in a layer of zinc chloride over the spelter.

Various hypotheses have been offered to explain the action of sodium chloride. These assume either a physical effect due to the entrainment of zinc vapor with the vapor of sodium chloride or a solution by the zinc chloride of any oxide coating formed on the condensed zinc particles. Although these may be contributing factors, the observations of Kiessling (*Berg. u. Hutt. Ztg.*, 1903, p. 613) have shown that sodium carbonate acts similarly to the chloride, though perhaps not quite so effectively. Since sodium carbonate is non-volatile and no zinc chloride can be formed, we must look for other explanations. A hypothesis is offered here which, though not free from objections, offers a basis for rational development.

The formation of blue powder is due to a reoxidation of the zinc by the carbon dioxide existing in the condenser according to the reversible reaction $ZnO + CO \rightleftarrows Zn + CO_2$. Researches by the American Zinc, Lead & Smelting Co. show quite conclusively that the percentage of carbon dioxide in equilibrium with a given mixture is greater at high than at low temperatures.

The presence of salt may be supposed to modify the reaction between ZnO and carbon thus:

$$2NaCl + ZnO + C \rightleftarrows 2Na + ZnCl_2 + CO$$

The amount of sodium chloride which reacts in this way is only a small percentage of the whole, the principal portion volatilizing as such. If the amount of zinc chloride formed is not large, it escapes from the condenser unnoticed, since the blue zinc flame is masked by the yellow of sodium. It also collects to some extent in the blue powder that is formed. The metallic sodium, being volatile, passes off with the zinc, and is the effective agent in reducing blue-powder formation, it does this by reducing the CO_2 content as the temperature falls, so that the sodium instead of the zinc is oxidized. Considering the two reactions,

$$2Na + CO_2 \rightleftarrows Na_2O + CO$$

$$\frac{C^2_{Na} \times C_{CO_2}}{C_{CO}} = K'$$

$$Zn + CO_2 \rightleftarrows ZnO + CO$$

$$\frac{C_{Zn} \times C_{CO_2}}{C_{CO}} = K''$$

K' is smaller than K'', and hence the sodium is oxidized and the zinc protected. Sodium carbonate would obviously effect the same result since the reaction

$$Na_2CO_3 + 2C \rightarrow 2Na + 3CO$$

is known to proceed at fairly high temperatures. It has the advantage of being non-volatile and producing no zinc chloride, hence causing no zinc loss from this source. Sodium carbonate, however, tends to form slag, hence is objectionable. It should be noted that spelter made with the use of sodium chloride usually contains traces of metallic sodium, which can readily be detected by the flame test.

Thus a substance to be effective in reducing blue-powder formation must contain a volatile element more easily oxidized than zinc.

Anaconda, Mont.

Fusibility of Ash From Pennsylvania Coals*

BY W. A. SELVIG AND A. C. FIELDNER

PREVIOUS papers[1] gave a description of the standard gas-furnace method used by the Bureau of Mines in making ash-fusibility tests, a discussion of the relation of fusibility tests to clinker formation and tables giving a summary of results obtained for the coals of West Virginia and the Interior Province. This paper includes a table giving a summary of such tests on the coals of Pennsylvania, which State is by far the greatest coal-producing state in the Union.

INTERPRETATION OF FUSIBILITY TABLE

The various coal beds of the bituminous coal field of Pennsylvania are arranged according to their geological succession, the uppermost beds being listed first. The

FUSIBILITY OF COAL ASH FROM PENNSYLVANIA COALS

Series, Bed	Number of Mines Sampled	Total Number of Samples	Average Softening Temperature, Degrees F.	Ash in Dry Coal, Average Per Cent	Sulphur in Dry Coal, Average Per Cent
BITUMINOUS REGION					
MONONGAHELA SERIES					
Pittsburgh Bed........	10	34	2360	7.17	1.43
CONEMAUGH SERIES					
Little Pittsburgh Bed..	1	2	2390	8.13	1.70
ALLEGHENY SERIES					
Upper Freeport (E or Lemon) Bed........	33	85	2350	9.35	2.13
Lower Freeport (D or Moshannon) Bed....	21	70	+2390	8.52	2.06
Upper Kittanning (C Prime) Bed.........	7	18	+2350	8.67	2.16
Middle Kittanning (C) Bed................	5	7	+2380	11.06	2.98
Lower Kittanning (Miller or B) Bed........	39	162	+2550	7.86	2.03
Fulton Bed...........	4	12	+2940	7.36	1.18
Brookville (A) Bed.....	3	3	+2800	12.98	1.86
POTTSVILLE SERIES					
Bloss Bed............	3	3	2630	11.96	2.25
ANTHRACITE REGION					
Northern Field					
Pittston District.......	1	1	+3010	6.03	0.58
Plymouth District.....	2	7	+3010	12.52	0.84
Scranton District......	6	7	+3010	12.39	0 79
Wilkes-Barre District	3	4	+3010	13.17	0.78
Eastern-Middle Field					
Hazelton District......	1	1	2960	14.50	0.61
Western-Middle Field					
Shamokin District.....	2	2	+2960	16.59	0.90
West Mahony District..	3	3	+3010	.....	....
Southern Field					
East Schuylkill District	2	2	2990	11.19	0.78
West Schuylkill District	1	1	2730	18.07	0.82

NOTE.—A plus sign (+) placed before a given value denotes that the true value is above that indicated.

samples are practically all standard mine samples collected according to the methods used by the Bureau of Mines.[2] A few car samples which were considered representative of the output of the various mines were also included.

The various coal districts of the anthracite region are arranged alphabetically under the field to which they belong. The samples are practically all delivery samples of the various sizes as marketed, only a few standard mine samples are represented.

VALUES AND SOFTENING TEMPERATURES

The number of mines sampled, number of samples represented, average softening temperature in degrees F., per cent ash and per cent sulphur on the dry coal basis are given for each bed tested in the bituminous coal field, and for each district in the anthracite region. Average values for each mine were computed from the individual samples, and from these values averages representing each bed or district were obtained. In some instances the average values given for the beds or districts represent only a few mines and are in such cases not truly representative. The point taken as the softening temperature is that at which the ash when molded into solid triangular pyrimids ¾-in. high and ¼-in. wide at the side of the base and mounted in a vertical position has fused down to a spherical lump. Samples remaining unfused at 3010 deg. F., which was the highest temperature attained in the test, were marked plus 3010 (+3010) and used as such in figuring the average values for the mine from which the average values of the beds or districts were computed.

DISCUSSION OF FUSIBILITY VALUES

As stated in a previous paper[1] on the fusibility of coal ash from the Interior Province coals, the softening temperature of coal ash from the various fields of the United States ranges in general from 1900 to 3100 deg. F. This range of softening temperature for convenience in discussion is subdivided into the three following groups:

Class 1, refractory ashes, softening above 2600 deg. F.

Class 2, ashes of medium fusibility, softening between 2200 and 2600 deg. F.

Class 3, easily fusible ashes, softening below 2200 deg. F.

The softening temperature of the ash from the bituminous coal field of Pennsylvania are found in Class 1 and Class 2, principally in the latter. The beds of the Monongahela, Conemaugh and Allegheny series, with the exception of the Lower Kittanning, Fulton and Brookville beds of the Allegheny series, are very uniform as regards to fusibility and come in Class 2. The Lower Kittanning bed of the Allegheny series contains a large number of mines which give ash of high fusibility, and the average for this bed almost places it in the lower part of Class 1. The Fulton and Brookville beds of the Allegheny series, as also the Bloss bed of the Pottsville series, come in Class 1.

OLDER BEDS SHOW HIGH SOFTENING TEMPERATURES

It is interesting to note that the coals that show high softening temperatures are geologically the lower and older beds of the bituminous coal field. This was also found to be true of the coal beds of West Virginia. It has been found that in general the beds of the Monongahela and Allegheny series of Pennsylvania give a more refractory ash than do the same beds as found in West Virginia.

The ash from the anthracite region of Pennsylvania is very refractory, coming in Class 1. The softening temperature in practically every instance is above 3000 deg. F.

Fuels Chemical Laboratory,
Pittsburgh Experiment Station,
Bureau of Mines.

*Published by permission of the Director, United States Bureau of Mines.

[1]Selvig, W. A.,: "Fusibility of Coal Ash From West Virginia Coals," CHEMICAL & METALLURGICAL ENGINEERING, Vol. 19, No. 12, 1918, pp. 826-828.

Selvig, W. A., Ratliff, W. C., and Fieldner, A. C.: "Fusibility of Coal Ash From the Interior Province Coals as Compared With West Virginia Coals," CHEMICAL & METALLURGICAL ENGINEERING, Vol. 20, No. 6, 1919, pp. 274-276.

For complete tables giving results obtained for each mine tested see: Selvig, W. A.: "Fusibility of Coal Ash From West Virginia Coals," *Coal Age*, Vol. 15, No. 1, 1919, pp. 12-16. Selvig, W. A. Ratliff, W. C., and Fieldner, A. C.: "Fusibility of Ash From Coals Found in the Interior Province," *Coal Age*, Vol. 15, No. 16, 1919, pp. 698-703.

[2]Holmes, J. A.: "The Sampling of Coal in the Mine," Technical Paper 1, Bureau of Mines, 1911, 18 pp.

Commercial Feasibility of Electric Smelting of Iron Ores in British Columbia*

Markets for Iron and Steel—Available Ore, Concentration of Low-Grade Magnetites—Cost of Electric Current Compared With Coke and Charcoal Reduction — Electrodes, Types of Furnaces—Cost of Plant and Smelting

A BRIEF abstract of Dr. Stansfield's main conclusions from his recent studies in British Columbia has already appeared in the columns of this journal (CHEMICAL & METALLURGICAL ENGINEERING, Vol. 20, p. 206, March 1, 1919). Appendices to his report constitute the bulk of its volume, containing material of large value to students of electric smelting, as well as shedding light upon the Western market for electric iron and steel.

MARKETS FOR IRON AND STEEL

Considerable divergence in opinion is recorded as to the British Columbian market for foundry pig iron—the most sizable outlet for simple furnace products. This is partially due to the fact that recent shortages and high prices have caused a considerable curtailment in custom founding, while recent shipbuilding is responsible for a large specialized output. During the year ended March 31, 1915, but 2341 tons of pig iron entered the ports of British Columbia and Alberta. Some probably was shipped from Eastern Canadian works, while considerable quantities of scrap are normally used in cupola work. This unquestionably augmented the supply, for 2341 tons of pig would be consumed in one sizable foundry in a month. Various men connected with the metal trades estimated that from 10,000 to 15,000 tons of foundry iron could be absorbed annually in British Columbia (apart from the shipbuilding industry) if the price could be made from \$30 to \$40 per ton, instead of the \$60 to \$70 ruling during the summer of 1918.

"Before the war, with Eastern prices about \$15 per long ton, the price in British Columbia would be between \$25 and \$30. While it is impossible to predict the course of prices after the war, it seems likely, in view of the high cost of living and the increasing powers of the working-classes, that the price of labor, and consequently the price of manufactured products, will not return again in the near future to the pre-war figures. If we may assume that Eastern prices of pig iron will not fall below \$20, it will follow that the normal price of pig iron in British Columbia will not fall below \$35, or at the lowest price \$30, for a period of several years.

"With regard to the possibility that a blast-furnace plant may be established in the State of Washington, and that it may capture the market for iron in British Columbia, I may state that the B. L. Thane Co. estimates the cost, under 1918 conditions, of making iron in the State of Washington at \$22, \$26 and \$30, on three assumptions with regard to the cost of supplies. Taking the middle estimate, \$26, and adding the freight, say \$2, and the Canadian duty of \$4.75, would raise the cost of iron delivered in British Columbia to about \$33; a figure which is about the same as the cost of making electric-furnace iron with power at \$15. The bounty offered by the British Columbia government would, apparently, turn the scale in the favor of the electric product. After the war the war duty of 7½ per cent *ad valorem* will no doubt be withdrawn, and in general we must expect that a blast-furnace plant on the Pacific coast would be able to take a part at least of the market in British Columbia for the cheaper grades of iron, but, with the help of the Canadian duty and the Provincial bounty, an electric smelting plant in British Columbia should be able to retain the local market for the higher grades of iron."

On account of the limited market for pig iron—which Dr. Stansfield estimates as 20 to 30 tons daily (at a price of \$35), the recommendation is for a small electric plant which can produce steel and ferros as well.

AVAILABLE ORE

The report goes into the available ore supply in considerable detail. With no iron furnaces operating in the western region, it is only natural that none of these deposits are developed. However, some large ore bodies near tidewater have been prospected with sufficient thoroughness to warrant the opinion of competent geologists and mining engineers that several million tons of 55 per cent magnetite, low in phosphorus and sulphur, can be easily delivered at tidewater furnaces at a cost of approximately \$4 per ton.

CONCENTRATION OF LOW-GRADE MAGNETITES

It is pointed out that it will oftentimes be cheaper to eliminate gangue mechanically than to slag it, especially by expensive electrical heat in a small furnace. As an instance, it is assumed that "the ore can be mined to contain 40 per cent of iron at a cost of \$1 per ton, where the 50 per cent ore cost \$2 to mine. Adding the fixed charge of 10c. and the royalty of 40c. (50c. for a 50 per cent ore), the crude ore will cost \$1,50 per ton. The crushing to 80 mesh and magnetic concentration may cost 80c. per ton, making a total of \$2.30. Suppose that 2 tons of ore yield 1 ton of a 70 per cent concentrate, then the cost will be \$4.60 per ton of concentrate. To this we must add a charge of, say, \$1 for sintering and \$1 for freight, making a total of \$6.60 per ton. This corresponds to \$9.45 per ton of pig iron, which is \$1.45 more than the cost using raw 50 per cent ore at \$4 a ton. The saving in the smelting process, due to the use of a richer ore, would be in the order of \$3 a ton of iron, thus making a saving of about \$1.55 per ton."

On the other hand, Dr. Stansfield thinks it would not be advisable to dress a 50 per cent ore up to 65 per cent, if it involved sintering the concentrate. As a matter of fact about 25 per cent of fine concentrated ore (so-called "slig") is used in Swedish practice, while it

*Excerpts from Bulletin No. 2, 1919, British Columbia Department of Mines, by Alfred Stansfield, D.Sc., Professor of Metallurgy, McGill University.

would be the exact material required for a metallizing operation.

"The possibility of the commercial operation of an electric-smelting plant for the production of pig iron from iron ore depends on an adequate supply of electric power at a moderate rate. A large amount of power is needed, the amount varying somewhat with the richness of the ore, the grade of iron to be produced, and the kind of furnace employed. Under usual conditions the consumption of electrical power for each long ton of pig iron lies between one-third and one-half of a horsepower-year. For the production of foundry iron from rather low-grade ores, and in a simple pit furnace, it will not be safe to count on the production of more than 2 long tons of iron per annum for each eleectric horsepower supplied to the works. For a production of 50 tons of pig iron daily some 8000 or 9000 electric horsepower will be needed, and if provision is made for the production of ferro-alloys and the making of steel in electric furnaces, some 10,000 to 15,000 hp. must be provided.

Cost of Electric Power for Smelting

"The power companies in Vancouver were unable, during my visit, to give me definite information on this point, but I understood that power could probably be provided at about $15 per electrical horsepower-year; a price at which it seemed possible that electric smelting could be undertaken commercially. When my report was nearing completion, I received a letter informing me that the charges for electric power would be nearly twice the figure I had assumed in my calculations. Under this changed condition the electric smelting of iron ores by existing methods is scarcely possible, and the only remaining opening, unless cheaper power can be obtained, is by developing a new process."

So much for the commercial current already available. It appears that there is ample undeveloped power going to waste, and Dr. Stansfield was furnished estimates showing that 340,000 hp. at three accessible points could be developed for smelting purposes at about $10 per horsepower-year.

Such costs would be lower than for ordinary users, since the load factor would easily approach 90 per cent. "The power factor of these furnaces has been found to be very high in Sweden, where the supply is one of 25 cycles, but in California, using a 60-cycle supply, the power factor of the [open pit] furnace has been found to vary from nearly unity when the furnace is empty to as low as 65 per cent when the furnace is ready for tapping. I should think, however, that if special attention were paid to this side of the design of furnace, it could be made to keep the power factor above 80 per cent at all times. Voltage regulation is effected by a series of taps on the primary of the service transformers, there being usually three such transformers for each furnace, which are independently regulated. On account of this the transformers are of special design, and the primary voltage would not be more than about 10,000, and preferably in the order of 2000.

"It will be understood that such development [of new power houses] would be out of the question at the present time in view of the high cost of labor and supplies, and the difficulty of obtaining apparatus.[1] It seems probable, however, that within a few years after the termination of the war, wages and costs in general will arrive at some more settled condition."

[1]The report was dated Nov. 11, 1918.

Up to ½ ton of charcoal or coke is needed for the reduction of a ton of pig iron, charcoal being preferred for its greater purity, its higher electrical resistance preventing short circuiting at the top of the charge, and its friability producing intimate contact between ore and reagent.

"Theoretically, 1 ton of foundry pig iron will need 0.269 ton of carbon for its reduction from magnetite and about 0.035 ton for its carburization, assuming it to contain 3.5 per cent of carbon. It will also need 0.026 ton of carbon for the reduction of 3 per cent of silicon. The combined carbon requirement will thus be 0.33 ton per ton of pig iron. On account of the well-known purity of wood charcoal, it is often assumed that it contains at least 90 per cent of carbon, and that some 0.38 ton of charcoal will be sufficient per ton of pig iron. Actually, however, charcoal contains from 70 to 75 per cent of fixed carbon; the average over a long period in Sweden being 73 per cent, the balance being volatile matter and moisture, and accordingly some 0.44 to 0.47 ton of charcoal must be provided. In view of the custom of weighing iron by the long ton and charcoal by the short ton, it appears that ½ net ton of charcoal will be required. There is, indeed, a small amount of reduction by carbon monoxide, even in the open furnace, but this will be balanced by the combustion of charcoal at the top of the furnace and the other mechanical losses. Assuming that 5 per cent of the carbon monoxide is utilized in the open furnace and 25 per cent in the Swedish furnace, we find that 0.4 net ton of charcoal should be enough in the latter type of furnace. Mr. Gronwall, in his estimate, quoted in my report on 'Electrothermic Smelting of Iron Ores in Sweden,' allows 0.370 metric ton of charcoal per metric ton of foundry iron, and this would be 0.414 net ton per long ton of pig iron. It will be seen, therefore, that my estimate is supported both by theoretical calculations and by the results of practice in Sweden.

Comparison of Coke and Charcoal

The comparative values of these as reducing materials depend in the first place on their fixed-carbon content. Thus, if charcoal contains 73 per cent of fixed carbon and coke 84 per cent, the coke would appear to be the more valuable. The remainder of the charcoal, however, is volatile matter and moisture, which is driven off harmlessly in the furnace, while the coke would contain some 13 per cent of ash, which has to be melted, and will usually necessitate the addition of a flux. The sulphur in the coke also will need fluxing, in addition to lowering the purity of the resulting pig iron. It follows, from these and other considerations, that charcoal is somewhat more valuable than coke as a reducing reagent. Referring to Mr. Gronwall's estimate in my Swedish report, the following figures show the relative consumption of fuel and of electric power for 1,000 kg. of pig iron, according as charcoal or coke is employed:

TABLE I. REDUCER AND ENERGY FOR SWEDISH FURNACE

	Using Charcoal of 73 Per Cent Carbon		Using Coke of 85 Per Cent Carbon	
	Kilos Fuel	Hp.-Year	Kilos Fuel	Hp.-Year
White pig iron	340	0.37	370	0.39
Gray pig iron	370	0.40	400	0.42

"At the present time no considerable quantity of charcoal is produced in British Columbia, and its price is now $30 a ton. However, large quantities of Douglas fir mill waste are available and suitable for carbonizing in charcoal-kilns, the yields in by-products being unimportant.

"The regular charcoal-kiln is a circular brick structure holding about 50 cords of wood. It is charged and discharged by hand, and the volatile by-products are partly saved by being drawn through condensers, the permanent gases being returned and burnt in the kiln. If a battery of these kilns were established at a large lumber-mill so that the waste wood could be delivered mechanically to the kilns, the production of a ton of charcoal might cost:

2½ cords of mill-waste at $1	$2.50
Labor and other expenses of operation after deducting the value of the by-products	2.50
Carriage of charcoal to smelter	1.00
Total	$6.00

"For the electric-smelting plant about 40 tons of charcoal would be needed daily. Each kiln would yield 20 tons, but as the process is slow, requiring about fifteen days, some thirty kilns would be required. If a charcoal industry were established in suitable relationship to the lumber industry, charcoal could be delivered to the smelter at a cost of about $6 or $8 per ton, corresponding to $3 or $4 per long ton of pig iron.

Electrodes

"The electrodes used in the Swedish furnaces at the time of my visit in 1914 were 24 in. in diameter and 4 or 5 ft. long. They were provided with threaded ends, so that fresh lengths could be added as the electrodes wore away. They were of amorphous carbon and cost about 4c. per lb. The consumption of electrodes, when making white pig iron from high-class ores, was about 10 to 15 lb. per ton of pig iron, thus costing about 50c. per ton of product. In melting lower grade ores for foundry iron the consumption might be from 15 to 20 lb.; at present prices in British Columbia this would mean about $1.50 per ton of pig. A furnace of 3000 kw. uses six of these 24-in. electrodes.

TABLE II. BECKMAN AND LINDEN'S ESTIMATE OF COST

300-Ton-per-Month Electrode Plant

Baking kilns complete, including all burning apparatus	$20,000
Hydraulic press (500 tons per month, 600-ton pressure)	6,000
Two mixers	6,000
Molds	5,000
Calciner complete	40,000
Building complete	25,000
Crane	8,000
Conveying equipment and elevators	2,500
Crushing and screening apparatus	3,000
Kiln-sand	1,000
Tools, chain, etc	1,000
Contingencies, 10 per cent	11,850
Engineering	15,000
Total	$144,350

Cost of Making 2000 Pounds of Electrodes

Anthracite coal, calcined, crushed and sized	$20.00
Pitch at $20 per ton	5.00
Baking fuel, pound per pound ratio	4.50
Labor, 50c. per hour	12.75
Operating superintendence	1.85
Supplies	1.00
Maintenance	2.00
Plant office expense	.75
Main office expense	4.00
Total	$51.85
Cost per lb., 2.6c.	

"At Bay Point, Cal., the 3,000-kw. open-pit furnace, smelting ferromanganese, uses three 24-in. carbon electrodes. The consumption is 100 lb. per ton of ferromanganese, and Beckman and Linden expect that in using this furnace for making pig iron the consumption would be 20 lb. per ton.

"Under ordinary conditions carbon electrodes cost 3c. or 4c. per lb. [see Table II], but at the present time the price in the East is about 8c., and on the Pacific coast nearly 10c. It is desirable to make electrodes locally, but this should not be undertaken until the smelting plant is in good running order."

"There is a fair supply of laborers at nearly $4 a day, and most skilled men are scarce at about $6 a day. The cost of labor per ton of iron depends very much on the size and output of the plant. Thus, in a fully equipped plant making 50 or 60 tons of pig iron, and steel and ferro-alloys as well, the cost of labor might be $4 or $5 per ton of iron, but if only one or two furnaces were operating the labor cost might be about $7 per ton of iron.

"At Hagfors three 3000-hp. furnaces are operated by fifty men, working 8 hours daily, at a wage of about 12c. per hour. At this rate, with bonuses and the higher rates of foremen, the cost would amount to about 80c. a ton of pig iron. In a plant of three 3000-kw. furnaces in British Columbia fifty men might be assumed to cost: Thirty at $4 and twenty at $6, or $240 a day. With an average output of 75 tons daily of foundry iron this would mean $3.20 per ton. A plant of this size would probably need a few additional men, say ten or twelve, which would increase the charge for labor to about $4 a ton.

TABLE III. DAILY LABOR FOR ONE 3,000-KW. PIT FURNACE

One furnace foreman at $8	$8.00
Twelve furnacemen at $5	60.00
One chief electrician at $6	6.00
Three sub-station operators at $5	15.00
Three mechanics at $6	18.00
Six mixing-men at $4	24.00
Six metal-handlers at $4	24.00
Two locomotive-crane men at $5	10.00
Total	$165.00

"With an output of 25 tons per day this would mean $6.60 per ton of iron."

Type of Furnace

1. *Electro-Metals Furnace Used in Sweden.* This furnace has been described repeatedly—for instance, in Dr. Stansfield's book, "The Electric Furnace," 1914 edition, pages 174-211—and is doubtless familiar to most readers. It consists of a furnace shaft, quite similar to an ordinary small iron blast-furnace stack, independently supported above a relatively shallow crucible of larger diameter, the latter covered with an annular arch through which project the electrodes. Furnace gases are ordinarily recirculated through tuyeres between the roof of the crucible and the descending charge, both to cool the roof and preheat the content of the shaft. Typical analyses of pig irons made in large tonnage in Sweden (Hagfors?) are:

	For Open-Hearth	For Lancashire Treatment	For Bessemer
Si	0.4 to 0.6	0.2 to 0.3	1.0 to 1.4
Mn	0.3 to 0.5	0.2 to 0.3	2.5 to 3.0
P	0.011 to 0.018	0.011 to 0.018	0.015 to 0.019
S	0.015	0.015 to 0.020	0.005

During the early operation of the plant there was a tendency for the sulphur to be unduly high, but this was remedied by making the slag more basic whenever the furnace was run for Lancashire pig.

Excellent bessemer has repeatedly been made. The early attempts were not good, but it was soon found that Si and Mn had to be increased. It had been assumed that the amount would be normal, but apparently the lower temperature of the electro-bessemer pig as compared with ordinary bessemer pig from blast-furnaces necessitates a higher content.

General experience points to the following results: It

is cheaper to make spiegel than gray pig, because: (1) More current can be put through the furnace; (2) the current consumption is lower (per ton of product); (3) thus the production is higher; (4) the electrode consumption is lower; (5) the repair costs are lower.

It may further be stated that rich charges give better economic results than poor ones. The quality of the pig, however, is not influenced by the percentage of iron content of the ore.

For some time past the gas from the furnaces has been used as fuel in the open-hearth furnaces, and it is estimated that the value of the gas is from 50c. to 75c. per ton of pig iron produced.

In large plants white pig can be made from 65 per cent ore with 0.31 hp.-yr. per ton, or gray pig with 0.37 hp.-yr. per ton. Smaller plants on account of a greater "diversity factor" would require perhaps 0.41 hp.-yr. per ton of gray iron, or 0.45 hp.-yr. if the ore ran not over 55 per cent iron.

The following furnaces of this style have been constructed:

SWEDEN

Trollhatten,	one 2250-kw. furnace; one 3000-kw. furnace.
Hagfors,	two 2250-kw. furnaces; three 4,000-kw. furnaces.
Domnarfvet,	one 7000-kw. furnace; four 3000-kw. furnaces, one 2000-kw. furnace.
Soderfors,	one 5000-kw. furnace.
Ljusne,	one 3000-kw. furnace.
Porjus,	two 3000-kw. furnaces.
Lulea,	three 3000-kw. furnaces.

NORWAY

Tyssedahl (Hardanger), two 2600-kw. furnaces.
Arendal, two 2000-kw. furnaces.

SWITZERLAND

Two furnaces.

JAPAN

Three furnaces.

ITALY

Aosta, six 3000-kw. furnaces.

2. *Helfenstein Furnace.* "The Helfenstein furnace was originally devised for the production of calcium carbide and ferrosilicon. [See R. Taussig, MET. & CHEM. ENG., X., 1912, page 686.] A 10,000-hp. furnace of this type for iron-smelting was started at Domnarfvet in May, 1913. A more recent account appeared in MET. & CHEM. ENG., May 1, 1917, page 509, from which I have taken the following particulars:

"When charcoal was used, the consumption of power, etc., was 2170 kw.-hr., 380 kg. charcoal (70 per cent carbon), and 5 kg. of electrodes per metric ton of pig iron. When coke was used, the consumption was 2600 to 2700 kw.-hr., 310 to 320 kg. of coke, and 4 kg. of electrodes. The consumption of 2170 kw.-hr. with charcoal corresponds to 0.392 hp.-yr. at 85 per cent load factor. This is probably for the production of white iron from high-grade ores, though at the time of my visit ores of 50 per cent iron were being smelted. It does not appear that the efficiency is any better than that of the Electro-Metals furnace, and it should be noticed that the use of coke causes the consumption of a far greater amount of electrical power.

"The idea of this furnace is to increase the output and efficiency by using a far larger amount of power in a furnace of a given size than was possible in the Electro-Metals furnace. The furnace gases were not used to reduce the ore in the furnace, but were employed for other purposes in the plant. It is unfortunate that we have no detailed account of the operation of this furnace, or of the reasons which caused it to be abandoned."

The furnace itself is essentially a tall open-pit furnace with openings in the side walls somewhat below the top through which the gaseous products of smelting are sucked into a bustle pipe, to be transported elsewhere for use.

3. *The Noble Furnace.* After considerable experimentation between the years 1907 and 1911, one 2000- and one 3000-kw. furnace similar in form were evolved by the Noble Electric Steel Co., at Heroult, Cal. The latter was substantially a covered rectangular shaft 28 ft. long, 10 ft. wide, lined with firebrick, charged through vertical chutes 18 ft. high, in which the cold ore descended without heating. Between charging chutes the furnace was arched over; through these arches were four 12-in. graphite electrodes.

"The best account of this furnace was written by John Crawford, the plant manager, in METALLURGICAL & CHEMICAL ENGINEERING, July, 1913, Vol. XI, p. 383. The furnace gases are not used for preheating or reducing the ore, but are led away and used under lime-kilns and charcoal-retorts. The electric current is supplied to the furnace at a voltage of from 40 to 80. He found that coke was less satisfactory than charcoal in this furnace, but that if the coke was crushed a mixture of 60 per cent coke and 40 per cent charcoal could be used with fair efficiency. The following is an analysis of a 200-ton lot shipped to a foundry for making steel castings:

	Per Cent
Silicon	2.880
Combined carbon	0.098
Graphite carbon	3.300
Sulphur	0.028
Phosphorus	0.031

"Mr. Crawford does not consider this type of furnace as efficient as the shaft type, but states that he has kept the power-consumption as low as 2200 kw.-hr. per ton of pig in a furnace of 300 kw. This would equal 0.40 hp.-yr. at 85 per cent load factor. He states, however, that the long and narrow type offers the possibility of building several furnace units on to each other, like copper blast-furnaces, and this would lessen the radiation and electrical losses and increase the efficiency. It would also enable part of the furnace to be repaired while the remainder was still in operation."

4. *The Open Pit Furnace.* This type has been developed for calcium carbide and ferro-alloys; while it has never been used in the manufacture of iron, Beckman and Linden believe it is suitable for this duty. These men built and operated the furnace at Bay Point, Cal., for the Pacific Electro-Metals Co., illustrated and briefly described in CHEMICAL & METALLURGICAL ENGINEERING, Aug. 1, 1918, Vol. 19, p. 115. This furnace is a rectangular steel furnace, 17 ft. long, 9 ft. wide, and 7 ft. high, lined with 4½ in. of firebrick, and with a 3-ft. bottom of carbon butts. Three 24-in. carbon electrodes operate through the open top, spaced 3 ft. 6 in. centers, the lower ends being submerged in the granular furnace burden, which is shoveled constantly into the open top, heaping full. Current at 70 to 100 volts is used.

"There can be no question that charcoal pig iron of any desired grade can be made in this kind of furnace, which is easily and cheaply built and repaired, and should be able to run for a long time without need of repair. By providing an ample supply of power the efficiency should be satisfactory, and may be expected to approach fairly closely to that of the Swedish furnace. The charcoal-consumption will certainly be higher, but, as a poorer quality charcoal can be used, this need not cause any additional expense. The power-consumption will probably be higher; but it is impossible to speak

positively on this point, because the loss in heat, due to the open top and the absence of a stack, may be largely balanced by the greater efficiency of a higher-powered furnace, and by the fact that stoppages for repairs will be fewer and less prolonged. The consumption of electrodes will probably be larger per ton of pig iron, because they are somewhat exposed to the air, and perhaps also on account of the greater current density used in these electrodes. It is difficult to avoid the conclusion that, in operating such a furnace for the commercial production of pig iron, the management would ultimately be obliged to close in the furnace-top, so as to remove the gases from the furnace room. The furnace, so closed in, would then resemble the Helfenstein or the Noble furnace.

"If, then, it is decided to smelt in an electric furnace other than the Swedish type, it would be practicable to start with a simple pit furnace as used for ferromanganese."

Cost of Plant

Electro-Metals of London estimated the 1918 cost of a 6-furnace plant in Canada as $540,000, or $9 per ton of yearly output. These figures are based on a similar installation for Ansaldo in Italy. A plant for pig iron of half that size Dr. Stansfield estimates to cost $350,000 to $400,000, including land, wharf, trackage, and rolling stock, and when making gray pig of rather lower grade ore (53 per cent) would reduce 9000 tons per annum per furnace. This figures to approximately $15 per ton of yearly output.

"In order to obtain an independent judgment in regard to the general arrangement and cost of an electric-smelting plant in British Columbia, I discussed the design with Mr. R. H. Stewart of Vancouver, and he contributed some general considerations in regard to the design and cost data for the general portions of the plant, exclusive of the electrical furnaces and appliances.

"The design was for a plant of 20,000 hp. (15,000 kw.) for the production of 100 tons of iron daily and 20 tons of ferro-alloys. The plant was designed to handle daily the following quantities:

	Tons
Iron ore	200
Charcoal	50
Limestone	20
Electrodes	2
Manganese ore	20
Quartz	10
Chrome ore	10
Scrap-steel	20

"Although the plant as a whole was based on a daily capacity of 100 tons of iron and 20 tons of ferro-alloys, the electrical and furnace equipment is only about half of this, corresponding to a consumption of 10,000 hp., or 7500 kw., and a production of 50 tons of pig iron and 5 tons of ferro-alloys, provision being made for extension at a later date.

"The furnace building would be 50 ft. wide, 30 ft. high and 150 ft. long. It would contain along one long side two 3000-kw. open furnaces for smelting iron ore and three 300-kw. open furnaces for ferro-alloys. On the other side of this wall would be the transformer building, 30 ft. wide and 30 ft. high. The supplies of ore for the furnaces would be delivered by an elevated track in front of the furnaces and level with the charging-platforms. The furnace gases would be removed by flues below the charging platform. The pig iron could be tapped into large ladles and cast in sand or in a casting-machine or poured direct into a bessemer converter for steel-making. The ores and other supplies coming by water would be unloaded into storage by a locomotive crane. The charcoal would need a large storage shed, perhaps 300 ft. long and 90 ft. wide, which would contain a month's supply, stored not more than 10 ft. deep.

"The order of operations would be as follows:—

(1.) Unloading from the dock directly into storage.
(2.) Removal from storage, using the same crane, to crushing and sampling plant.
(3.) Removal from crushing plant to the furnace charge-bins.
(4.) Delivering from charge-bins over weighing-hoppers to the charge-cars and thence to the side of the furnace.
(5.) Smelting for pig iron or ferro-alloy.
(6.) Molten pig iron received in ladle and handled by crane to casting-bed or casting-machine or to steel-making furnace.
(7.) The slag would be received in a ladle and removed by a locomotive.

"The following is based on Mr. Stewart's estimate for the cost of buildings and general plant. Items for the [open pit] furnaces and electrical equipment have been added from Beckman and Linden's estimate:

20,000-HP. PLANT WITH 7000 KW. OF ELECTRIC FURNACES AND EQUIPMENT

Mr. Stewart's items:	
Locomotive crane, buckets and grab-buckets	$19,000
Dock, say	10,000
Electric locomotive, cars and equipment for handling between the wharf and the crushing plant	10,000
Crushing and sampling, say	17,000
Charcoal storage for one month's supply	8,000
Tracks, etc., for the above-mentioned equipment	3,500
Lifting-magnet for steel scrap, etc	1,200
Storage of manganese ore	3,500
Storehouse for electrodes and other supplies, including a small crane	6,000
Six furnace charging-bins, including weighing-hoppers and mechanical feeders	9,000
Tracks, charge-cars, and locomotive, with supports for the overhead track	10,000
Furnace building, including crane runway	25,000
Transformer building	12,000
3- to 10-ton ladles	6,000
Flues and stacks	25,000
20-ton crane, 50-ft. span	18,000
Laboratory and equipment	6,000
Office	5,000
Machine-shop and blacksmith's shop	12,000
Wash-house and change-room	3,000
Slag-handling equipment	8,000
Items from Messrs. Beckman and Linden:	
Two 3000-kw. 3-phase furnaces, installed	30,000
Seven 1000-kw. single-phase transformers	45,500
Two sets low-tension buses for 3000-kw. furnaces	10,000
Two sets high-tension buses, etc., for 3000-kw. furnaces	12,000
Three 300-kw. single-phase furnaces, installed	10,000
Four 300-kw. transformers, installed	10,000
Three 50-kw. single-phase transformers	2,000
One 25-kw. motor-generator set for regulators	2,000
Three sets low-tension buses for 300-kw. furnaces	1,500
Land, say	6,000
Engineering and contingencies, 20 per cent on $129,000	25,800
Total	$372,000

"Modifying this estimate to represent a plant of 9000 kw. making pig iron only, we have:

9,000-KW. PLANT FOR PIG IRON

Mr. Stewart's items	$217,000
Three 3000-kw. furnaces	45,000
Eleven 1000-kw. transformers	71,000
Three sets low-tension buses	15,000
Three sets high-tension buses, etc	18,000
Three 100-kw. transformers	3,000
One 25-kw. motor-generator	2,000
Land	6,000
Engineering, etc., 20 per cent on $160,000	32,000
Total	$409,000

"These figures agree with the previous estimate of $400,000."

Cost of Making Pig Iron in Swedish Furnace

Table IV contains available and estimated costs by Swedish practice. Costs from Electro-Metals are for a large plant, and show what can be done under exceptionally favorable conditions. Mr. Leffler's figures appeared in *Iron Age*, Sept. 13, 1917, p. 605. The increased amount in Stansfield's estimate is due in about equal proportions to the increased charges for ore power and labor. Items in Dr. Stansfield's estimates are

explained in previous sections, and interest is taken on $400,000 for plant plus $100,000 working capital, while 10 per cent depreciation (somewhat moderate) is figured on the plant.

Conversion of White Iron Into Foundry Pig

"On account of the fact that the Swedish furnace is generally used for the production of a white pig iron containing not more than about 1 per cent of silicon, we have no exact data for the production of foundry iron of, say, 3 per cent of silicon in this furnace. We are satisfied, however, that there would be a decided increase on this account in the cost for power, charcoal, electrodes and maintenance, besides the general overhead, labor and interest charges. In view of this, it is worth while to consider what the cost would be of converting white iron into foundry iron by the addition of ferrosilicon. One ton of iron containing 1 per cent of silicon would need the addition of 0.04 ton of 50 per cent ferrosilicon to raise its silicon content to 3 per cent. This ferrosilicon would cost, made in the plant, about $85 per ton, or $3.50 for the amount needed.

"If the pig iron were received in a large ladle and the ferro were thrown in red hot, there should be enough heat to effect a perfect mixture; and as the iron is cast into pigs for sale, and then remelted in a cupola, any irregularity would be remedied before the final casting. The saving in the cost of smelting through producing white iron instead of foundry iron would about equal the cost of the ferrosilicon, and there would be the added advantage of making a single furnace product and turning as much of this as was needed into foundry iron.

Difference in Cost

"Mr. Gronwall, in his estimate in 1914, places the difference in cost between gray and white pig iron as:

0.03 ton of charcoal.
0.03 horsepower-year.
5 lb. of electrodes.
10 cents for repairs.
7 cents for petty charges.

"Under our conditions this would mean:

Charcoal at $8	$0.24
Power at $15	.45
Electrodes at 8 cents	.40
Repairs and petty charges	.21
Total	$1.30

"We must add, however, a proportion of the charges for labor, management, and fixed charges amounting to about 60c., thus bringing the whole up to $1.90. The additional expense may easily be as much as 0.05 ton of charcoal and 0.05 hp.-yr., and the increased cost would then be about $3 a ton (everything considered), or nearly as much as the cost of the ferrosilicon addition.

"The ferrosilicon used was found to cost $3.50, but, as it replaces an equal weight of pig iron costing $1, the net cost of the addition will only be $2.50 per ton of the resulting foundry iron.

"The foregoing discussion is not intended to prove that the addition of ferrosilicon to white iron is the best way of making foundry iron, but merely that the use of the Swedish furnace for foundry iron would be perfectly safe, because ferrosilicon could be added without much additional expense if it were found impracticable to make foundry iron directly."

Cost of Smelting in Pit Furnace

Dr. Stansfield conservatively assumes the following power and charcoal used per long ton of iron in a pit furnace:

	Hp.-Yr.	Net Ton Charcoal
White iron from 65 per cent concentrate	0.35	0.45
White iron from 50 per cent ore	0.43	0.45
Gray iron from 65 per cent concentrate	0.42	0.50
Gray iron from 50 per cent ore	0.50	0.50

On such a basis the cost of making one long ton of foundry pig in pit furnaces (10,000-kw. plant) is as shown in Table V.

TABLE V. COST OF IRON FROM PIT FURNACE

	From 55 per Cent Ore			From 65 per Cent Concentrate		
	Quantity	Price	Amount	Quantity	Price	Amount
Iron ore	2 tons	$4.00	$8.00	1.43 tons	$6.97	$10.30
Electrical power	0.5 hp.-yr.	15.00	7.50	0.42 hp.-yr.	15.00	6.30
Charcoal	0.5 ton	6.00	3.00	0.5 ton	6.00	3.00
Electrodes	20 lb.	.10	2.00	20 lb.	.10	2.00
Flux	....	....	?	....	....	......
Labor	....	....	6.00	....	....	6.40
Supplies	....	....	1.00	....	....	1.00
Plant and general office expenses	....	....	3.00	....	....	5.00
Interest and depreciation	20% on $120,000		3.00	20% on $140,000		2.81
Total			$33.50	Total	....	$36.81

In all the above estimates it should be carefully noted that electric energy was assumed to cost $15 per hp.-yr., the understanding which the author held until shortly before his report was written, as already noted above in the section on "Cost of Electric Power for Smelting." Charges of ½c. per kw.-hr. quoted him later are so high as to render impossible any large-scale production of electric pig iron in the Swedish or open-pit furnace.

Comparison With Blast-Furnace Methods

"It may be of value to compare with my estimate of the cost of making pig iron in the Swedish furnace the following estimates by the B. L. Thane Co. of the cost

TABLE IV. COST WITH SWEDISH FURNACES

	European Plant by Electro-Metals		North Sweden by J. A. Leffler		British Columbian 1918 by A. Stansfield		British Columbian Minimum by A. Stansfield	
Capacity per annum	60,000 tons white iron		?		27,000 tons gray iron		27,000 tons gray iron	
Ore	1¼ tons	$1.50	1.6 tons	$4.38	2 tons	$8.00	1.7 tons	$5.00
Flux	¼ ton	.50	....	.16	....	......	....	......
Charcoal	0.33 ton	2.00	0.4 ton	5.00	0.4 ton	3.20	0.4 ton	3.20
Electrodes	10 lb.	.50	....	.44	15 lb.	1.20	15 lb.	.60
Electric current	0.31 hp.-yr.	2.50	0.365 hp.-yr.	3.46	0.45 hp.-yr.	6.75	0.45 hp.-yr.	4.50
Repairs and maintenance	....	.50	....	.88	....	1.00	....	1.00
Labor	....	2.00	....	1.56	....	4.50	....	4.50
Management	....	1.00	....	.54	....	2.00	....	2.00
Interest and depreciation	....	1.00	....	.86	6 and 10%	2.60	6 and 10%	2.60
Royalty	....	......	....	.34	....	.50	....	.50
Rents	....	......	....	1.38	....	......	....	......
Carriage to market	....	......	....	1.16	....	......	....	......
Total cost	....	$11.50	....	$20.16	....	$29.75	....	$23.90

TABLE VI. COST OF FERRO-ALLOYS

	80% Ferromanganese 300-Kw. Furnace			Silicomanganese 60% Mn; 20% Si 3000-Kw. Furnace			65% Ferrochromium 300-Kw. Furnace			50% Ferrosilicon 3000-Kw. Furnace		
	Quantity	Rate	Amount	Quantity	Rate	Amount	Quantity	Rate	Amount	Quantity	Rate	Amount
Ore	2.7 T 40%	$25	$67.50	3200 lb.	$25/T	$40.00	3 T 40%	$36.00	$108.00	....	....	....
Steel turnings	300 lb.	$10/T	1.30	440 lb.	$10/T	2.00	100 lb.	$11/T	.50	1500 lb.	$10/T	$7.50
Lime rock	1500 lb.	$3/T	2.25	....	....	....	....	....	....	....	....	....
Silica rock	....	....	....	380 lb.	$4/T	.80	....	....	....	2400 lb.	$3.50/T	4.20
Coke and charcoal	1400 lb.	$8/T	5.60	1800 lb.	$8/T	7.20	1350 lb.	$8	5.40	1200 lb.	$8	4.80
Electrodes	150 lb.	7c.	10.50	100 lb.	7c.	7.00	100 lb.	7c.	7.00	60 lb.	7c.	4.20
Power	0.9 hp.-yr.	$15	13.50	0.8 hp.-yr.	$15	12.00	1.4 hp.-yr.	$15	21.00	1 hp.-yr.	$15	15.00
Labor	....	....	8.00	....	....	8.00	....	....	12.00	....	....	16.00
Maintenance	....	....	5.00	....	....	5.00	....	....	5.00	....	....	....
Supplies	....	....	2.00	....	....	1.50	....	....	2.00	....	....	1.50
Plant expense	....	....	3.00	....	....	3.00	....	....	10.00	....	.... }	15.00
Office expense	....	....	6.00	....	....	6.00	....	....	6.00	....	.... }	
	....	....	$124.65	....	....	$92.50	....	....	$176.90	....	....	$68.20

of making pig iron in a large blast-furnace near Puget Sound at 1918 prices:

B. L. THANE COMPANY'S ESTIMATE OF THE COST PER LONG TON OF BLAST-FURNACE PIG IRON

Iron ore, 3,457 lb. at $4.40 per long ton	$6.81
Coke, 2,485 lb. at $9.60 per net ton	11.93
Limestone, 1,000 lb. at $1.90 per long ton	.81
Labor	1.50
Materials	1.50
Capital charges	3.40
Total	$25.95

"There does not appear to be any cause, other than the different size of the furnaces, why electric-furnace iron should cost more than blast-furnace iron under the conditions we find on the Coast, and providing that power can be obtained at $15 or less.

Auxiliary Industries

"In view of the limited market for foundry pig iron in British Columbia, it will be essential to make other products, so as to increase the output of the plant. For this purpose an additional output of low-silicon pig iron can be made, and this can be melted with steel scrap for the production of steel. Ferro-alloys, such as ferrosilicon, ferromanganese and ferrochrome, can also be made in an electric-smelting plant. These auxiliary industries not only increase the general output of the plant, thus reducing, proportionately, the overhead charges, but are themselves likely to yield a higher profit than the production of pig iron."

Attached is Table VI giving the itemized cost of various ferros.

On the basis of power at 0.5c. per kw.-hr., 80 per cent ferromanganese would cost $136.15 per ton. In 1913 this alloy sold in the Eastern States at $50 per long ton. [On April 15, 1919, this journal quoted $130 to $150 per long ton.]

A small furnace making silicomanganese with 0.5c. per kw.-hr. power would cost about $110 per ton. [Silicomanganese is not in general use among American steel plants.]

On the basis of power at 0.5c. per kw.-hr., 65 per cent ferrochromium would cost $194.40 per ton. [Such ferrochromium was quoted in this journal on April 15, 1919, at from $416 to $520 per short ton.]

On the basis of power at 0.5c. per kw.-hr., 50 per cent ferrosilicon would cost $81 per ton. In 1913 this alloy sold at $73 per ton. In October, 1918, it is quoted at $160 per ton, and on April 15, 1919, it was from $90 to $150 per gross ton.

"In order to be able to make pig iron on as large a scale as possible, and also with a view to combining more profitable industries with that of iron-smelting, it is desirable to introduce into the electric-smelting plant furnaces and other appliances for making steel. The general scheme suggested is that about 25 tons of foundry iron should be produced daily for sale to iron-foundries, and a further 25 or 30 tons of white pig iron should be made for conversion into steel in the same plant or elsewhere. The steel would probably be made in small open-hearth furnaces heated by oil, or in electric furnaces of the Heroult type. Together with 30 tons of pig iron, about 60 tons of steel scrap could be used if desirable, thus yielding about 85 tons of steel daily. This could be used in part for making steel castings, and the remainder could be rolled into rods and bars of small section in a small rolling-mill. I may add the following estimate, made by Lyon & Keeney in 1915, for the cost of electric steel-making in the Western States (*Trans.*, Amer. Electrochem. Soc., 1915, XXVII., page 158):

COST OF PRODUCTION OF ONE LONG TON OF STEEL IN THE ELECTRIC FURNACE IN THE WESTERN STATES

1.1 tons of scrap at $15 per ton	$16.50
Slag materials	1.00
Ferro-alloys	1.00
800 kw.-hr. at 0.20c.	1.60
Labor	2.50
Maintenance and repairs	2.40
20 lb. of electrodes at 5c.	1.00
Amortization and depreciation at 5 per cent each	1.50
Interest at 6 per cent	.90
General	1.00
Royalty	.50
Total	$29.90

"The present cost of making steel in British Columbia will be considerably higher than this estimate, on account of the higher cost of supplies and operation."

Edgewood Arsenal Has New Commanding Officer

Edgewood Arsenal, which is the Gas Offensive Division of the Chemical Warfare Service, U. S. A., has now come under the command of Lieut.-Col. Amos A. Fries, Corps of Engineers, (C. W. S.), U. S. A., who as Brigadier-General, National Army, A. E. F., commanded the C. W. S. forces throughout the war in France.

Col. William H. Walker, formerly of the Massachusetts Institute of Technology, Boston, who has been the commanding officer of Edgewood Arsenal, has been honored with a Distinguished Service Medal by the Secretary of War and is now returning to pursue his profession in civil life.

Edgewood Arsenal, with its headquarters at 311 West Monument St., Baltimore, has arsenals located at Edgewood, Md.; Hastings-on-Hudson, N. Y.; Kingsport, Tenn.; Midland, Mich., and South Charleston, W. Va. The arsenals formerly located at Stamford, Conn.; Bound Brook, N. J.; Niagara Falls, N. Y., and Buffalo, N. Y., have been sold.

Decision on Frasch Patents on Sulphur Mining

BY HUGO MOCK AND ASHER BLUM

THE Circuit Court of Appeals of the Third Circuit, which is a Federal Appellate Court having jurisdiction over the States of Pennsylvania, Delaware and New Jersey, rendered the following decision in March which, as the Court states, "involves basic matters affecting the whole sulphur product of the United States."

A proper comprehension of this extremely important decision, which enables the Freeport Texas Co. and other concerns owning sulphur beds similar to the enormous deposit found in Louisana to compete with the Union Sulphur Co., requires a brief historical survey of sulphur mining as originated and practiced in America.

Prior to the development of sulphur mining in America, nine-tenths of the world's supply was produced in Sicily by extremely primitive methods which involved shafting and other ordinary methods used in mining. In 1869 an enormous deposit of sulphur was discovered in Louisana when a well was being drilled for oil. All efforts to mine this proved unsuccessful for twenty-five years until Herman Frasch took up the problem.

COURT EULOGIZES MR. FRASCH

The Court pays a handsome tribute to Mr. Frasch, who, it states, "in inventive fertility and past experience seemed to be the one man to solve the difficulty and successfully work out one of the most remarkable wonders of world commerce."

Mr. Frasch resolved to give up the mining methods and shafting which had proved ineffectual because of the presence of quicksand and water and because of the presence of sulphurous gases which had killed several men. Mr. Frasch was very experienced in oil well work and his "daring, original and inventive step" consisted in forcing hot water into the sulphur bed so as to melt the sulphur, and then pumping up the molten sulphur to the surface and separating it from the water.

In 1890, Mr. Frasch filed applications in the United States Patent Office which resulted in the grant of U. S. Patent No. 461,429 for a process of mining sulphur, and Patent No. 461,430, which covered apparatus for mining sulphur, and these patents were issued on Oct. 20, 1891, so that by operation of law they would expire on Oct. 20, 1908, and then become free, public property. A third patent, No. 461,361, also issued on the same day, but it played no importance in the decision.

THE FIRST FRASCH PATENT

In the U. S. Patent No. 461,429 Mr. Frasch stated that his method was useful for sulphur deposits which were overlaid with beds of quicksand which therefore prevented shafting. The method disclosed in this patent required that an ordinary well should be drilled through the limestone above the sulphur, a casing being forced through this limestone and through the quicksand by the ordinary methods used in drilling oil wells and the like. This shut off water and the quicksand. When the casing reached the sulphur, a hole of smaller diameter was continued to the bottom of the sulphur deposit. Tubing of smaller diameter than the casing was then passed through the casing and the hole in the sulphur in a central position, and this tubing was passed above the ground to a casing head. Water at about 270 to 280 deg. Fahrenheit was then forced down by a pump between the tubing and the casing to the bottom of the hole in the sulphur, where it melted the sulphur and forced it up through the tubing to proper separators.

U. S. Patent No. 461,430 also showed a pump at the bottom of the tubing which could be used to raise the molten sulphur. Thus the mine could be filled with hot water to melt the sulphur and the sulphur could be periodically removed by this pump. A modification of this apparatus showed a bleed pipe extending from the surface of the ground to the hole in the mine, the bottom of the bleed being higher than the bottom of the casing and tubing. This bleed pipe could be used to draw off the hot water while the sulphur was pumped up by the pump before mentioned.

Frasch's first well was drilled in the fall of 1894 and was worked for four or five hours, producing about 500 bbl. of sulphur, when mechanical difficulties due to the sulphur corroding the iron-working parts of the valve and pump, and the weakness of the boiler used to supply the hot water, caused the stoppage of operations.

WHY COMPLETE COMMERCIAL SUCCESS WAS DELAYED

Various reasons delayed complete commercial success until 1903, but the Court stated, "We are satisfied that such delay and difficulties were not caused by defects in Frasch's original conception or in means to utilize it. As already pointed out, Frasch was immersed in other work; he regarded this as a side issue; his visits were infrequent; the work was frequently suspended, for as much as a year at a time; the finances were such that the work was badly hampered."

In the meantime, and before commercial success had been secured, Frasch filed another application, on May 27, 1897, which resulted in the issuance of two patents on Sept. 19, 1905, 799,642 and 800,127. In addition, Frasch was also granted U. S. Patent No. 1,008,319 on Nov. 14, 1911.

In U. S. Patent No. 799,642, Frasch stated that his earlier patents were unsatisfactory because since the sulphur had been found to be porous he could not develop sufficient pressure with the water pump to raise the column of molten sulphur and that a lifting pump gave trouble with its valves. In addition, the water with which the deposit of sulphur was saturated cooled the incoming hot water so that the yield of sulphur was small. The novelty in this patent consisted in not returning the water to the surface, but forcing it out through the porous rock so as to heat it even when the temperature of the water was below the melting point of sulphur. The water was now forced in at about 300 deg. Fahrenheit to counteract the effect of the cold water in the porous deposit.

FRASCH'S LATER PATENT

The apparatus shown in this patent showed a pipe corresponding to the casing of the earlier patents, which was driven down to the rock. An inner and centrally located hot water pipe was then passed through the casing to the bottom of the sulphur. This hot water pipe had a plug at its bottom and was perforated above the plug so as to allow the hot water to escape into the mine. A sulphur-raising pipe of less diameter than the hot water pipe was centrally located therein and was connected with the plug of the hot water pipe. The bottom of the sulphur-raising pipe was provided with a strainer and had an air-injecting pipe located

therein which was provided with a perforated bottom piece. Of course all these pipes extended to the surface of the ground. The bottom of the casing, or mine pipe as it is called, was higher than the bottom of the hot water pipe. Hot water was forced into the mine pipe and also into the hot water pipe, so as to fill them to a certain height. The hot water issuing from the mining pipe melted the sulphur and caused it collect around the bottom of the hot water pipe and the sulphur-raising and air-injecting pipes so as to seal them, while the water from the hot water pipe flowed directly over the molten sulphur and kept it hot. The hot water was allowed to flow away through the surrounding porous rock. Air was injected from the air pipe until the density of the sulphur was lowered to about that of water so that it could be easily raised by the column of water in the hot water pipe.

U. S. Patent No. 800,127 had about the same disclosure as No. 799,642, and mentioned that no provision was made for the return of the hot water which was forced out through the walls of the cavity in the sulphur and into the walls of the surrounding rock. U. S. Patent No. 1,008,319 covered the idea of injecting the hot water into the mine through a strainer so as to divide the stream of hot water over a wider zone and prevent clogging.

Union Sulphur Co's Claims

The Union Sulphur Co., which had acquired these three later patents, sued upon claims 2, 3, 6, 12, 19, 21 and 22 of No. 799,642, upon claims 2, 3, 7, 11, 21 and 24 of No. 800,127, and upon claims 7, 20 and 28 of No. 1,008,319.

The claims of No. 799,642 attempted to cover particularly the following points:

1. The forcing of water heated above the temperature at which melted sulphur begins to darken into the deposit and out through the surrounding rock, and removing the melted sulphur.
2. The use of injected air to lessen the density of the sulphur.
3. The injection of hot water into the cavity in the sulphur at two different levels, that is, one from the casing or mine pipe and another from the hot water pipe.

The claims of No. 800,127 in issue attempted to cover the apparatus for carrying out the above-mentioned process. The three claims of No. 1,008,319 attempted to cover the point already defined, namely, spraying out the hot water through a strainer.

Importance of the Litigation

The great importance of the litigation consisted in the fact that the porous character of the sulphur deposit made sulphur mining in America impractical unless the process and mechanism disclosed in the later patents and covered by these claims were used, so that if these claims would have been sustained the Union Sulphur Co. would have had a monopoly at least up to Sept. 19, 1922, when its patents No. 799,642 and No. 800,127 would expire.

The Union Sulphur Co. contended that when Frasch commenced his operations and applied for his patents issued in 1891 he was absolutely ignorant of the porous character of the Louisana sulphur deposit and that he believed that it was impervious to water, which was alleged to be the case in the Sicilian sulphur deposits, and that the earlier Frasch patents were valueless and impracticable, while the later Frasch patents involved an advance over them of great practical merit.

The Freeport Texas Co. contended that Frasch well knew from the very inception of his operations that the Louisiana deposit was porous and that the later Frasch patents represented nothing novel or patentable over his earlier patents, but were merely an attempt to stretch out the monopoly of the Union Sulphur Co. so that it would have the control of the American sulphur market from 1908 to 1922, and it pointed out that while Frasch had filed his second series of patents in 1897 the actual issuance of these patents had been delayed until 1905.

The Court's Decision

The Court very carefully analyzed all the testimony in a decision covering eighteen printed pages, and it came to the conclusion that since Frasch had examined a sample of the Louisana sulphur and from other circumstances he was well acquainted with the porous character of the Louisana deposit from the commencement of his work and that there was no basis for any patentable novelty in the later patents. The Court held that it involved no invention to apply the hot water at two different levels instead of at one, as was done in the first Frasch patents, or to use air pressure as a means of bringing the liquefied sulphur to the surface, and that Frasch's former patents were not restricted to a tight and non-porous rock. The Court also held that to distribute the hot water through a perforated lining was a common mechanical expedient and involved no invention. Accordingly, it ordered the complaint of the Union Sulphur Co. to be dismissed.

Does Not Bar Other Suits Elsewhere

This decision does not prevent the Union Sulphur Co. from bringing a like suit against some other company which may be located outside of the States of Pennsylvania, Delaware and New Jersey, and while the Federal Courts outside of the Third Circuit would feel inclined to follow the decision of this Circuit Court of Appeals, they are not bound to do so, and since a number of cases have arisen where the Circuit Courts of Appeals of different circuits have disagreed in their decisions upon the same patents, there is a possibility of the patents being sustained in some other of the nine judicial circuits into which the country is divided. The Supreme Court may still exercise its discretion to review the decision of the Circuit Court of Appeals of the Third Circuit and this will almost certainly follow as a matter of course if some other Circuit Court of Appeals disagrees with the Circuit Court of Appeals of the Third Circuit, as in such event the Supreme Court finally passes upon the case, so as to cause uniformity of authority throughout the entire country.

New York, N. Y.

Removal of Tin Import Restrictions

Applications for licenses to import tin ore and tin concentrates will be considered by the War Trade Board. These licenses will permit the importation of shipments made from points of origin on or after June 8, 1919, and will not be valid for entry until July 1.

Civil Service Examination.—Applications will be received until July 1 for the position of superintendent of heat treatment. There is a vacancy in the U. S. Naval Ordnance Plant, South Charleston, W. Va., at $5000 a year.

Kingsport, Tennessee, and Its Chemical Industries—II

A Brief Historical Survey of a Progressive Young American City, With a Technical Description of Its Varied Chemical Plants and Their Processes—Coal-Tar Dyestuffs and Intermediates—Tannery and Tanning Extract Plant—Wood Pulp

THE plant now owned and controlled by the Union Dye & Chemical Corporation was built by the Federal Dyestuff & Chemical Co. in 1915-16. Operations were begun in 1916, and after a brief career, the Federal Co. went into the hands of a receiver in 1918. On Aug. 15, the same year, the plant was sold by the receiver to the Union Dye & Chemical Corporation, Chester A. Jayne, president, J. F. White, general manager, and J. J. Bajda, technical director. The company is capitalized for $3,000,000 and has offices at 2 Rector St., New York, N. Y.

The new company is not only manufacturing the products of its predecessor, but is planning and preparing to greatly expand its scope, and to place on the market a line of chemicals, dyestuffs and intermediates far more extensive than the limited variety produced by the former owners of the plant. Buildings and equipment are being overhauled and remodeled, and new machinery is being installed, preparatory to instituting substantial economies in operating methods, and to producing the best grade of goods at lowest possible cost.

The principal colors now being manufactured are sulphur black, sulphur blue, sulphur red, sulphur brown, sulphur green, sulphur yellow and sulphur maroon. Other chemicals now being produced for sale are: Aniline and its derivatives, ortho- and para-toluidine, azo colors, intermediates, caustic soda, monochlorbenzol, bleaching powder, hydrochloric acid, nitric acid, and alizarine dyes.

It should be understood that on account of the keen competition in the dye industry, it is impossible to publish very many of the details of equipment or of processes in this plant. As some of these processes have been worked out after much painstaking and expensive research work, necessarily the nature of the materials used and of the chemical reactions involved in the dye-making processes cannot be fully disclosed.

All power used at this plant, as at all the industrial plants of Kingsport, is obtained from the Kingsport Utilities Corporation. No interruptions to this power are experienced, but in case for any reason this power should fail, the dye company could generate its own power. The company has two air compressors, and is now installing an ice plant, the manufactured ice and the cold circulating brine to be used in its chemical processes. The boiler house is equipped with two Henry Vogt Machine Co. boilers, 300 hp. each, and these furnish steam for heating and drying purposes.

Sulphur Black and Sulphur Blue

Sulphur black is made in the dinitrochlorbenzol nitrating building. Monochlorbenzol is treated with a mixture of nitric and sulphuric acids of high concentration in nitrators (of which three have been installed), heated with steam coils. The product of this treatment is dinitrochlorbenzol. This is blown into fusion kettles, and from there to oxidizing kettles, where it undergoes further treatment, and is then filter-pressed and dried by vacuum and steam. The product, known as crude sulphur black, is sent to the standardization department, and here it is analyzed and brought to standard strength. This dye, known as standard sulphur black, is then packed in strong wooden barrels, containing about 500 lb. each, for shipment. It is used for dyeing cotton or wool, but not for silk.

The process for the manufacture of sulphur blue is practically a duplication of the sulphur black process, with, of course, the necessary substitution of chemicals. The starting point for sulphur blue is indophenol. This is blown first into fusion kettles, then into oxidizing kettles, where it is oxidized, and is then filter-pressed. From the filters, the crude sulphur blue is sent to the drying room, where it is placed on trays, which are arranged on shelves in the hot air cupboard, and subjected to a blast of hot air, which passes over and under the shelves. The dried dye is then sent to the standardizing department, where it is standardized, and is then placed in ball mixers (revolving steel drums containing iron balls), where the dye is crushed to powder. Sulphur blue is used for dyeing cotton, wool and silk. The capacity for the manufacture of sulphur blue or black is practically unlimited, the output being determined by the demand.

Nitrobenzol and Nitrosophenol

Nitrobenzol is manufactured by the usual process of mixing benzol with a mixture of nitric and sulphuric acids of high concentration. The acid mixture consists of 29 per cent HNO_3, 61 per cent H_2SO_4, and 10 per cent water. The chemicals are heated in steam jacketed nitrators, each provided with an agitator, manufactured by the Buffalo Foundry & Machine Co. There are four of these nitrators, each 10 ft. high by 6.5 ft. in diameter. The reaction takes place at 140 to 150 deg. C. When the reaction is completed, the nitrobenzol is blown to the nitrobenzol wash-house. Here the nitrobenzol is washed four times in a wooden vat provided with an agitator. The washed nitrobenzol is then drawn off into a blowcase, and blown to the aniline plant, where it is received in twelve feed tanks, supplying twelve reducers. The latter are steel cylinders on end, 10 ft. high by 8 ft. in diameter, each heated by a steam coil and provided with an agitator. The nitrobenzol is fed into the reducer, along with iron borings screened to 40-mesh size. Heat is applied and the reaction starts immediately. The mixture is agitated continuously for from 24 to 36 hours. As the reaction proceeds, the temperature is gradually increased, and the aniline vapors pass off through a 6-in. pipe to condensers, which are steel cylinders, 25 ft. high by 6 ft. in diameter. Here the vapors are condensed, and the liquid is collected in receiving flasks.

Nitrosophenol is manufactured as follows: Phenol and caustic soda are mixed in one tank, and water,

UNION DYE AND CHEMICAL CORPORATION

sodium nitrite and sulphuric acid in another. The two liquid mixtures are then agitated together in a tank provided with a mechanical stirrer revolving at the rate of 38 r.p.m. The product, nitrosophenol, is filtered, then centrifuged. The time required for the manufacture is about six hours. Nitrosophenol must be handled in containers made of steel or other non-combustible material. Indophenol is made by combining nitrosophenol, sulphuric acid and orthotoluidine in condensation tanks equipped with agitators and brine coils. When the reaction is completed the indophenol is allowed to flow into tanks, where it is precipitated by means of sodium carbonate. After precipitation is completed, the indophenol (an intermediate used in the manufacture of sulphur blue) is filter-pressed. After filtering, the indophenol still carries about 50 per cent of moisture. It is placed in buggies and used in the sulphur blue department. The total time required for the manufacture of indophenol is eight hours.

Chlorine for making the monochlorbenzol used in the manufacture of sulphur black is made in the electrolytic cell house. A solution of common salt is electrolyzed in the Allen-Moore cell, manufactured by the Electron Chemical Co., 347 Madison Ave., New York City. There are three series of cells, 136 cells to a series, or 408 cells in all. Caustic soda is made here as a by-product. The caustic solution goes to evaporators, where it is concentrated to a strength of 30 per cent. The strong solution is then pumped to cooling tanks, cooled, and the salt settled out. The caustic solution then passes to storage tanks, and thence to the finishing department, where the caustic is brought to the solid state, and packed in drums for shipment.

In the still house, containing three stills, liquid residues from the various manufacturing operations go through a fractionating process for the recovery of benzol, monochlorbenzol and dichlorbenzol.

In the chlorination house benzol and chlorine come into contact with each other in counter current, in Lummus chlorination columns, of which there are six. The product, monochlorbenzol (used in the manufacture of sulphur black) is pumped to a washer and washed, and is then pumped to storage tanks for use as needed. The exit gas escaping from the top of the chlorination columns goes through a cooler, then to the hydrochloric acid house. The latter contains three towers, arranged in series, built of acid-proof stoneware furnished by the United States Stoneware Co. of Akron, Ohio, and packed with acid-proof brick and 6-in. spiral rings. The liquid flows from tower to tower in a direction opposite to that taken by the gas. The liquid is elevated to the tops of the towers by pulsometers made of chemical stoneware (likewise furnished by the United States Stoneware Co.), through 1-in. glass tubes. All of the hydrochloric acid manufactured is placed on the market.

Nitric Acid Department

In the nitric acid department there are four retorts now operating, and four more will soon be installed. The retorts, manufactured by the Pratt Engineering Company of Atlanta, Ga., take a charge of 7000 lb. of nitrate of soda each. Sulphuric acid 66 deg. B., recovered from the spent acids used in other manufacturing processes, is added to the retorts, and the mixture distilled. The fumes are condensed in S-shaped Duriron pipes sprayed with water, and the gases uncondensed there go through a series of five chemical stoneware towers, the five towers serving as a common condensing system for the four retorts. The last tower of the series is fed with water, and the liquid then goes from tower to tower in a direction opposite to that taken by the gas. As in the hydrochloric acid plant, the liquid is pumped to the tops of the towers by means of chemical stoneware pulsometers through 1-in. glass tubes.

The nitric acid condensed in the S-condensers, after passing through Duriron bleachers, is received in Duriron flasks. Two grades of nitric acid are made—a strong acid, made in the condensers, and a weak one, made in the towers. The strong grade is used in the sulphur black process, where only 4 per cent of water is allowable in the acid mixture; while the weaker grade is used for the manufacture of nitrobenzol, where the water in the acid mixture may be as high as 10 per cent.

To make the mixed acid used in the dye-making processes, the nitric acid is pumped into a steel mixer equipped with an agitator, and is there mixed with oleum, which is purchased from the General Chemical Co., of Pulaski, Va.

The spent acid recovery plant is for the recovery of sulphuric acid from the spent acids used in other manu-

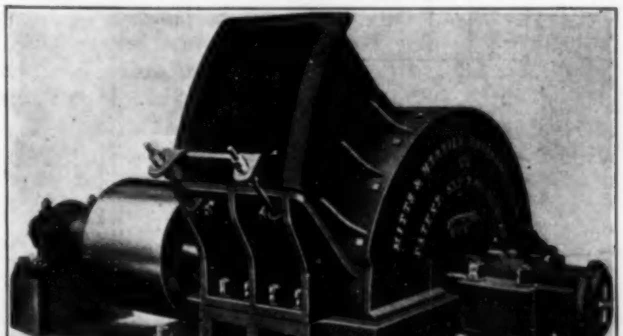
facturing processes. The spent acid is fed into a tower made of acid-proof brick, and packed with chemical brick and 6-in. spiral rings, up which pass the combustion gases from the furnaces used to heat two benches of pan concentrators. The acid discharged from the tower divides, and goes to both of these two benches, each of which consists of three cast-iron pans arranged in cascade and in series. The 66 deg. acid flows from the lowest pan of each series into a cooler, and this is sent to the nitric acid department to be used in the manufacture of nitric acid.

Tannery and Tanning Extract Plant

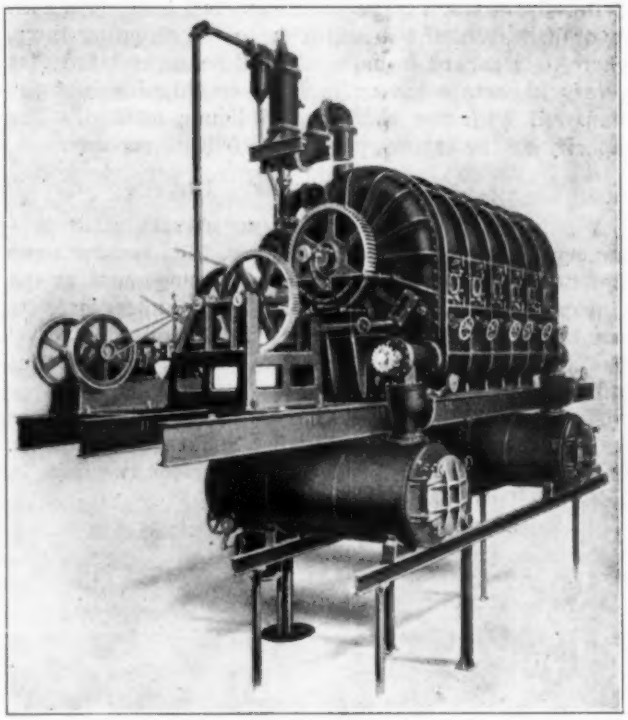
The latest industrial development of Kingsport is the Lang-Grant Leather Corporation, recently organized by the Simmons Hardware Co. of St. Louis, Mo. On the first day of April, this year, this recently organized company took over the control of the plants of the Kingsport Extract Corporation and of the Kingsport Tannery, Inc., both recently purchased for the purpose of consolidation with a new plant, already under construction, for the manufacture of finished leather goods, such as harness, saddles, horse collars and gloves. The existing plants will be described briefly first, and then the plans of the new organization for the future will be discussed.

The Kingsport Extract Corporation manufactures tanning extract from chestnut wood, oak bark and hemlock bark, all of which abound in the vicinity. From these raw materials, three different kinds of extract are made, chestnut, oak and hemlock. The first step in the manufacture of tanning extract is to shred, or chip, the wood, and grind the bark. The bark is put through a bark mill, and the ground bark is then delivered to the leaching vats. The chestnut wood is put through a chipper, commonly called by the extract men a "hog," manufactured by Mitts & Merrill, Saginaw, Mich. From the chipper the wood goes to a shredder, made by the Jeffrey Manufacturing Co., Columbus, Ohio. The wood, as discharged from the Jeffrey shredder, is not in the most desirable condition for conversion into paper pulp, and since the erection of the neighboring pulp mill, which now utilizes a large proportion of the spent chestnut chips of the extract company, the wood destined to reach the pulp mill is chipped by passing it through a Carthage disc chipper, made by the Carthage Machine Co., Carthage, N. Y.

In whatever way the wood may be comminuted, the chips are delivered to the vats and treated with water and steam. There are three sets of vats, eight vats to a set, each vat 14 ft. in diameter by 15 ft. high. Of the eight vats in a set, one will be loading chips, one discharging spent chips, and six in service. The solution is pumped in series from one vat to the next in the set, a fresh supply of water being introduced in the vat containing the chips which are most nearly spent, and the strongest liquor going to the vat containing a new batch of chips. Thus, as the liquor proceeds from vat to vat, it comes in contact with chips containing more and more undissolved tannin, and so the solution becomes stronger and stronger. Steam is introduced into one vat only—the first, containing the fresh supply of water and the nearly spent chips.



WOOD CHIPPER



VACUUM DRUM DRIER

After coming in contact with a new batch of chips, the strong solution is withdrawn, and is then evaporated under 14 in. vacuum in copper evaporating pans heated by copper steam coils manufactured by Jos. Oat & Sons, Philadelphia, Pa. The evaporation here is carried to 65 deg. as indicated by the barkometer. There are four of these evaporators, three large and one small.

The concentrated solution obtained from these evaporators is further evaporated to a powder in the vacuum drum drier, manufactured by the Buffalo Foundry & Machine Co.

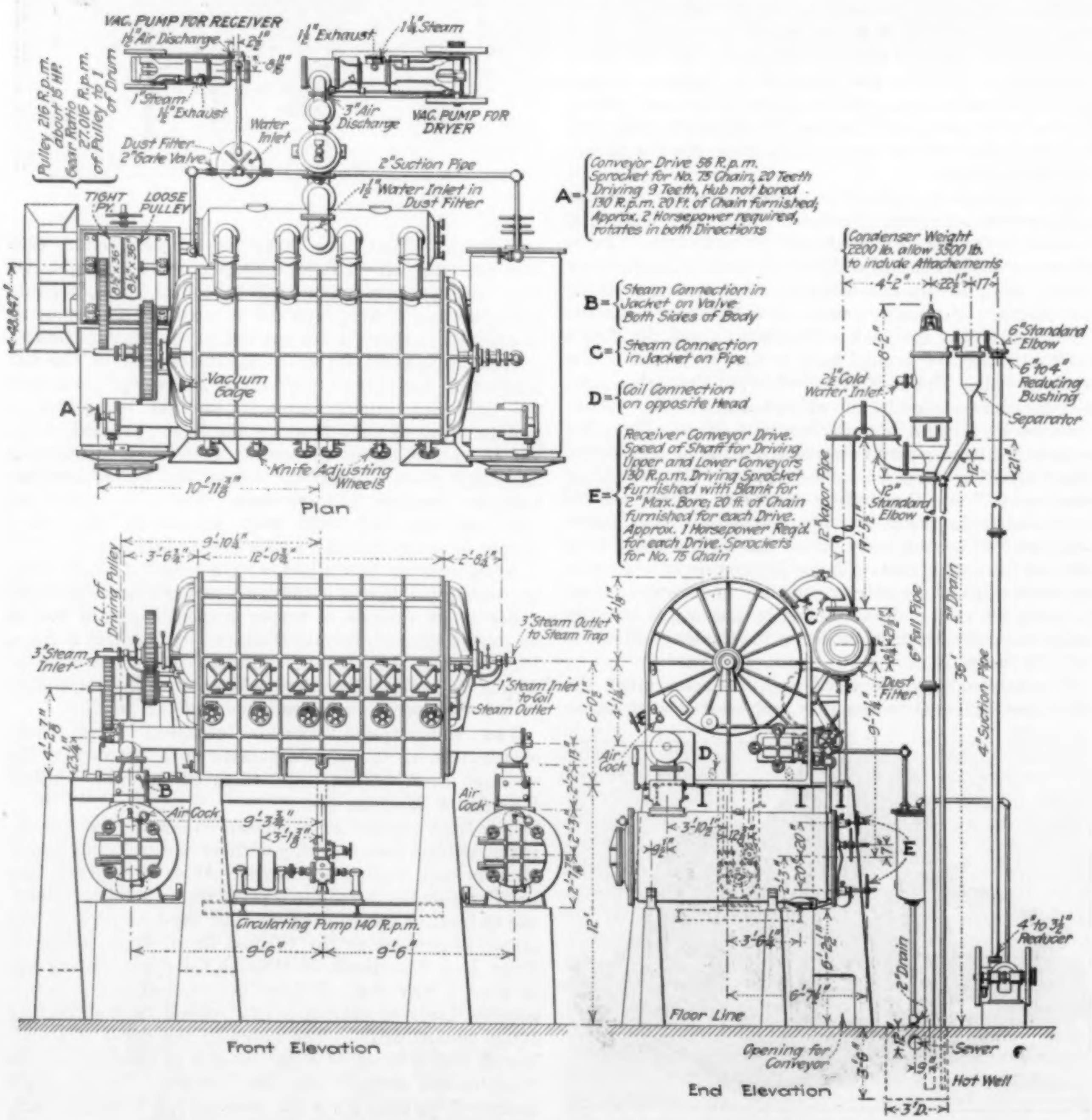
The high content of wood sap sugars in the concentrated extract makes drying without caramelizing impossible in bulk boiling processes. After the extract has been evaporated in bulk to a point where solids are tending to form on the heating walls of the concentrator, the liquor is pumped to the vacuum drum drier reservoir. From here it is circulated through the drum coating pan in such a way that all foam is removed and a homogeneous layer of extract syrup applied to the rotating steam heated drum. The speed of the drum is so adjusted that a layer of dried extract is obtained at the scrapers and dropped into the conveyor. Twenty-eight inches of vacuum gives the necessary low boiling temperature and there is no possibility of burning or oxi-

dizing the extract. The flaked extract goes by a conveyor belt from the drum drier to the shipping room, where it is packed in bags. It will be appreciated that a very important saving is made in shipping costs as compared with the old barreled liquor method. The capacity of the extract plant is 45,000 lb. per day.

Kingsport Tannery, Inc.

A natural adjunct to a tanning extract plant is a tannery, and the Kingsport Tannery, Inc., has for some time been operated under the same management as the Kingsport Extract Corporation. Every tannery uses its own blend of tanning extracts. The blend adopted by the Kingsport Tannery consists of 80 per cent chestnut and 20 per cent oak.

The raw hides as received from the slaughter houses are folded and tied up in bundles about 16 in. square. They are unfolded, and soaked in water for two days to eliminate dirt and blood. They are then placed in vats, where they are treated with a solution of lime for five days, during that time being reeled over from one vat to another, getting a little stronger solution of lime each day. They are then put into warm water, and depilated. After that the hides are "fleshed," i.e. all adhering bits of flesh are cut away by experienced workmen. The hides are then put into cold water to "plump" them, and are then put into "handlers," or vats containing the tanning solution. After 12 days they are put into "layways," or vats, where the hides are piled, with bark spread between them, and which are then filled up with tanning liquor. The tanning liquor may be changed five times or more, depending on the grade of leather to be made, using stronger liquor each time. If the leather is to be used for belting butts, after passing through the "handlers" the bellies are trimmed off with sharp knives. The bellies are then used for making



PLAN, END AND FRONT ELEVATION OF VACUUM DRUM DRIER

sole leather. After a preliminary drying process the bellies, having gone through the layways, are dipped in water and oiled, and are then passed through a roller and rolled into sole leather—irregular-shaped strips about a foot wide and 6 ft. long. The sole leather goes to a drying loft.

After treatment in the layways the belting butts (or hides with the bellies and shoulders cut off) are oiled with cod oil, and then are hung up in a dry loft, or "tunnel," through which air is blown, and dried for ten days, the temperature of drying being gradually raised to 95-100 deg. F.

The tannery making leather for sale in the general market sells it by the pound. It is therefore to the advantage of the tannery to add weight to its product. This is done without any unnecessary display or advertising by allowing the hides to spend a long time in some of the processes, and under this method of procedure, which benefits the leather manufacturer but does not improve the quality of the leather, six months are consumed in transforming a hide into leather. The complete process can, however, be done in two months; hence it is easy to see, from the greatly reduced amount of capital tied up in stock in process and the improved quality of material, the economies to be derived from the consolidation of a tannery with a factory for the production of finished leather goods.

The present capacity of the tannery is 125 hides per day, but under the new management this will soon be increased to 500 per day.

Lang-Grant Leather Corporation

As stated above, the tanning extract plant and the tannery have been purchased by the Lang-Grant Leather Corporation, which is now building and will operate, in conjunction with the existing plants, extensive additions to the present tannery, and a large new plant for the manufacture of harness, saddles, horse collars and gloves. The capital stock of the new company is $4,000,000. The enterprise will operate under the management of J. Harry Lang and R. Y. Grant. A site of 12 acres has been secured for the plant buildings. The building now being constructed is four stories high, 440 ft. long by 120 ft. wide, with two wings, 64 ft. by 50 ft., and 35 ft. by 70 ft. respectively, both three stories high. The building in which the saddlery will be manufactured will be 1200 ft. long by 100 ft. wide. The new buildings will be constructed of brick and concrete, the building materials being all made in Kingsport.

An idea of the magnitude of the proposed operations is gained from the statement that 400 tons of rye straw, locally grown, will be used annually in the production of horse collars alone. It is stated that the new enterprise when completed will employ 1200 to 1500 men, more than half of whom will be skilled mechanics. It can easily be realized that there is already great activity in the building of dwellings for housing the expected large increase in the population of the city.

Kingsport Pulp Corporation

The plant of the Kingsport Pulp Corporation was built in 1916-17, and was first operated in 1917. The capital stock of the company is $1,000,000. The principal officers are: President, Royal B. Embree; treasurer, J. C. Stone; general manager, J. H. Thickens; mill manager, J. E. Wetherbee. The plant was designed by George F. Hardy of New York City.

The reasons for the location of the plant at Kingsport, aside from the cheap power available, were existence of the tanning extract plant, which could supply 50 per cent of the raw material needed, in the form of extracted chestnut wood chips, and the abundance of hard woods in the vicinity, which would provide the other 50 per cent. The kinds of wood used, besides the chips from the extract plant, are poplar, cucumber and black and sweet gum. The capacity of the plant is 100 cords of wood a day.

The first step, as applied to the cord wood, is the stripping of the bark. This done, the wood goes to the chipper house, where it passes through a chipper made by the Carthage Machine Co., Carthage, N. Y., and under the chipper to a bucket elevator, which elevates the chips to a revolving screen, also manufactured by the Carthage Machine Co. This screen is a double one, and is shaped like the frustum of a cone, lying on its side. It is 30 ft. long by 4 ft. in diameter at the upper end, enlarging to 9 ft. at the lower end, and is placed at a pitch of 4 ft. in 30 ft. of length. The inner screen has meshes of 1½ in., the outer one, ¼ in. Sawdust escapes through the outer screen and goes to the boilers. The chips remaining on the inside of the inner screen go to a crusher, where they are reduced in size, and then join the chips which are caught between the two screens, going by conveyor to a bucket elevator, by which they are hoisted to the chip bins, which have a capacity of 100 cords of wood, or sufficient for one day's run.

The next step is digestion of the chips with caustic soda solution. There are ten digestors, built by the American Welding Co., of Carbondale, Pa., and made of seamless welded steel ⅝ in. thick, each 7 ft. in diameter by 30 ft. high. A solution of caustic soda is made, by treating soda ash with lime, in a Dorr system of tanks, six in all, each 30 ft. in diameter by 10 ft. deep. This is a continuous causticizing process. The strength of the solution as used in the digesters is 12 deg. B. The digester is charged with five cords of chips and 3500 gal. of caustic liquor, and is then sealed air tight.

The mass is then cooked with steam injected into the solution under a pressure of 110 lb. for 7¾ hours. At the end of that time the entire contents of the digester escape through a valve at the bottom into a blow-tower on the roof, being blown up there by the steam pressure in the digester. From the blow-tower the pulp goes to any one of four wash pans. These are of steel, and are 16 ft. in diameter by 7 ft. deep, fitted with a perforated false bottom which allows the liquor to drain off and retains all the pulp. The liquor goes back to the recovery process for the recovery of caustic soda. The pulp is washed for five or six hours, and is then delivered to the screen room. The wash water is discharged into the sewer.

The screen room contains eight screens, which are rectangular boxes about 10 ft. long by 4 ft. wide by 1 ft. deep, whose bottoms consist of ten brass plates, each a foot wide, containing many narrow slits 4½ in. long by 10/1000 in. in width. This screen, called the Improved Packer Pulp Screen, is made at Hudson Falls, N. Y. The wood fiber is drawn through the narrow slits by vacuum, the vacuum being alternately applied and released 700 times a minute by special machinery. All the fiber suitable for pulp making goes through the slits, and the oversize is rejected and goes to waste.

The material passing through the screen consists of 99.5 per cent water and 0.5 per cent fiber. This liquid goes through an iron pipe to one of two Decker-Wet

machines, manufactured by the Thompson Manufacturing Co., Lancaster, N. H. Here all trace of soda ash, lime, etc., is washed out, and the mass is brought to a concentration of 90 per cent water and 10 per cent fiber. The pulp now goes to the Belmer bleachers, of which there are six, manufactured by the Thorn & White Co., Philadelphia, Pa. Here a bleaching powder solution, 3.5 deg. B. in strength, is added. The function of the Belmer machine is to cause a continuous circulation of the stock through a system of tanks, during the bleaching process, which requires about five hours. After the bleaching is completed, the stock is dumped into one long tank, which extends under all six of the bleachers. The stock is then washed again, over a triple Decker-Wet machine, and then goes to a pulp-drying machine built by J. H. Horne & Sons Co., Lawrence, Mass. Here the pulp passes through an elaborate system of rolls, some of them steam-heated, by which it is dried, and is then cut into suitable sizes and rolled into bundles suitable for shipment.

The output of this plant is 50 tons of pulp a day. The quality made is excellent, the color a pure white, and it is used by paper makers for the manufacture of calendared paper such as is used by the better class of magazines.

Recovery of Caustic Soda

The liquor escaping from the false-bottomed tanks in the wash room is piped to two Yaryan evaporators, made by the Yaryan Co. of New York City. This type of evaporator is a 22-coil, triple effect machine. The first effect operates under 30-lb. pressure, the second effect under 9 in. of vacuum, and the third effect under 24 in. of vacuum. The solution enters the evaporator at 5 deg. B., and is discharged at 35 deg. B. It then goes by pipe line to a tank, and thence flows to one of two incinerators, where all water is expelled and the mass is burned to black ash. The incinerator is a revolving steel cylinder, on its side, 12 ft. in diameter by 15 ft. long, lined with 8 in. of fire brick. The woody matter of the caustic solution is burned at a very high temperature, said to be 2500 to 2800 deg. F. The recovery of black ash per day amounts to 60,000 lb., equivalent to 75 to 90 per cent of the caustic soda used. The black ash is distributed to leaching cells, where it is leached under 25 lb. pressure, and the solution is returned to the causticizing room, where it is used in the production of cooking solution.

The recovered solution as received at the mixing tanks in the causticizing room is of various strengths. Quicklime and soda ash are added to bring the solution to the strength desired. For mixing the caustic solution there are three steel mixing tanks, 9 ft. deep by 11 ft. in diameter, each provided with agitators, and perforated basket for slaking the lime. When the solution strength is properly adjusted, it goes to the Dorr system of tanks previously described.

The proper proportions for making caustic soda, assuming no recovered black ash solution to be used, are 5500 lb. of soda ash to 5650 lb. of quicklime. The quicklime is obtained from the neighboring plant of the Clinchfield Portland Cement Co. The actual consumption of quicklime per day is 50,000 to 55,000 lb., and of soda ash, 12,000 to 15,000 lb., the consumption of the latter being greatly reduced by the use of recovered black ash.

This concludes the description, necessarily brief and incomplete, of Kingsport and its chemical industries. One can hardly fail to notice how the plants are linked to one another. The utilities company supplies all the plants with power, and with water for drinking and fire purposes. The brick and cement companies supply themselves and all the rest with building materials. The dye works produces dye for the hosiery mill, and bleaching powder for the pulp mill. The cement plant furnishes lime for the industrial alcohol plant, the dye works, the tannery and the pulp mill. The extract plant supplies tanning extract for the tannery and extracted wood chips for the pulp mill, and the tannery will provide the new saddlery and harness factory with leather. If co-operation is the life of trade, the industries of Kingsport should thrive indeed.

Opportunity must be taken here to express appreciation of the courtesies extended by J. Fred Johnson, president of the Kingsport Improvement Corporation; by S. P. Platt, assistant to Mr. Johnson, and by the several managers and superintendents of the Kingsport plants who made possible this description of the chemical industries of an interesting community.

Imports and Exports

The Bureau of Foreign and Domestic Commerce of the U. S. Department of Commerce reports for March, 1919:

IMPORTS OF LEAD AND ZINC INTO THE U. S. BY COUNTRIES, AND FOREIGN AND DOMESTIC EXPORTS FROM THE U. S. TO ALL COUNTRIES

Imports			
Articles and Countries	Gross Weight, Tons	Contents, Lb.	Value
Lead ore:			
Canada	1,151	1,329,994	$52,704
Mexico	1,485	164,098	7,479
Peru	40	18,402	1,025
Total	2,676	1,512,494	$61,208
	Lb.	Lb.	Value
Lead and bullion and base bullion:			
Mexico	8,215,349	7,937,167	$317,106
Lead pigs, bars and old:			
Canada	....	52	3
Mexico	....	602,178	30,072
Jamaica	....	12,896	523
Chile	....	8,399	144
Total	....	623,525	30,742
	Tons	Lb.	Value
Zinc ore and calcamine:			
Canada	540	358,605	$7,940
Mexico	2,163	1,455,537	17,760
Total	2,703	1,814,142	25,700
		Lb.	Value
Zinc Dust:			
England	....	6,720	$1,270
Foreign Exports			
	Tons	Lb.	Value
Lead bullion and base bullion	....	....	....
Lead pigs and bars	....	709,435	$40,761
Zinc ore and calcamine	....	....	....
Zinc blocks or pigs and old	....	....	....
Zinc dust	....	....	....
Domestic Exports			
		Lb.	Value
Lead pigs, domestic ore		4,289,414	$254,668
Lead pigs, foreign ore		2,635,524	147,051
Zinc spelter, domestic ore		14,373,192	1,172,939
Zinc spelter, foreign ore		1,786,277	171,266
Zinc in sheets		5,368,115	762,904

IMPORTS OF TUNGSTEN-BEARING ORES INTO THE U. S. BY COUNTRIES—DOMESTIC EXPORTS OF TUNGSTEN AND FERROTUNGSTEN FROM THE U. S. TO ALL COUNTRIES

Imports of Tungsten-Bearing Ores

Countries	Tons	Value
Chile	24	$20,818
Peru	38	37,486
China	98	51,405
Hongkong	504	502,523
Japan	11	13,388
Total	675	$625,620

Exports of Tungsten and Ferro-Tungsten

Countries	Lb.	Value
Switzerland	1,400	$4,500
Canada	2,596	10,070
Australia	43	100
Total	4,039	$14,670

Synopsis of Recent Chemical and Metallurgical Literature

Electrometallurgy of Molybdenum.—According to an article by J. ESCARD in the *Revue Générale de l'Electricité*, Vol. IV, No. 11, Sept. 14, 1918, molybdenite, MoS_2, is treated in an electric furnace for molybdenum either directly or with molybdenum dioxide.

I. Direct Treatment of Molybdenite. The molybdenite is simply heated in an electric furnace and a fairly pure molybdenum is obtained. In heating a mixture of molybdenite and molybdenum dioxide in the electric furnace the following reaction takes place:

$$MoS_2 + 2MoO_2 = 3Mo + 2SO_2$$

and the product obtained has about 98.5 per cent Mo, with only about 0.7 per cent sulphur. When the mixture of molybdenite, carbon and lime is heated in the electric furnace the reaction is:

$$MoS_2 + 2C + 2CaO = Mo + 2CaS + 2CO$$

but this molybdenum still contains 3 to 4 per cent sulphur. When treating in a resistance furnace a mixture of molybdenite, lime and calcium fluoride, the product obtained is Mo_2S_3 if the current is high, 600 to 800 amperes and 110 volts, but with a current of 70 to 100 amperes and about 35 volts, and eliminating the iron with hydrochloric acid, the product obtained is 98.95 per cent Mo and 0.67 per cent Fe.

II. Treatment of Molybdenum Dioxide. The molybdenum dioxide is reduced with carbon. The following reactions take place:

$$2MoO_2 + 5C = CMo_2 + 4CO$$
$$2CMo_2 + MoO_2 = 5Mo + 2CO$$

The product obtained has one of the following compositions:

	No. 1	No. 2	No. 3
Molybdenum	99.98	99.73	99.78
Carbon	0.00	0.01	0.00
Slag	0.13	0.28	0.17
	100.11	100.02	99.95

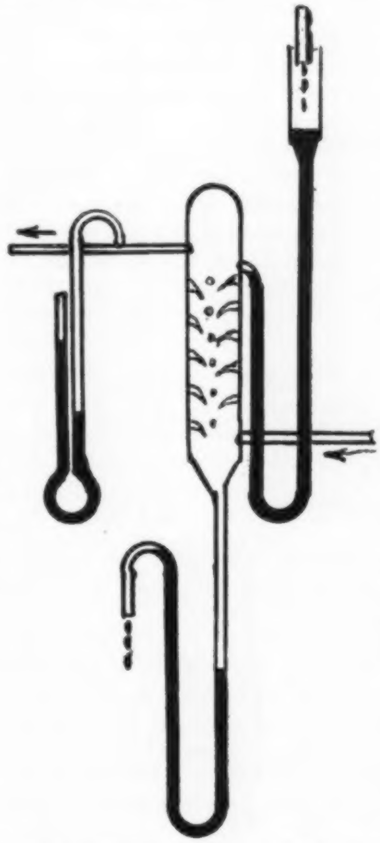
The molybdenum dioxide can be replaced by calcium molybdate in the presence of alumina when admixed with molybdenum carbide, as per the reaction

$$9CMo_2 + 3MoO_4Ca + Al_2O_3 = 21Mo + Al_2O_3 \cdot 3CaO + 9CO$$

In the preparation of electric wires the carbon filaments are subjected to the thermic action of an electric current in the presence of hydrogen in an atmosphere of molybdenum pentachloride ($MoCl_5$). This is transformed into molybdenum carbide, then finely pulverized molybdenum dioxide is added and the same reaction as above takes place, giving the pure molybdenum metal.

Continuous Testing of Gas With Special Reference to Acid or Alkaline Constituents.—In the course of working a plant for the recovery of ammonia from Mond gas, the need was felt for some form of apparatus which would indicate at any time whether complete absorption of ammonia was being effected, or whether some ammonia was passing through the plant, with consequent loss in the recovery of ammonium sulphate. The apparatus devised is described by C. A. KING in the *Journal of the Society of Chemical Industry*, London, England, Feb. 15, 1919, which serves for the continuous testing of alkalinity or neutrality of a gas.

The gas from the outlet main is caused to pass upward toward a small glass absorption chamber about 7 cm. long and 1.5 cm. diameter, provided with projections from the inner wall to effect more efficient contact with a solution of a suitable indicator which flows from a U-shaped tube into the upper end of the extraction chamber. The indicator solution drains away from the lower end of the absorption chamber through a similarly shaped tube in which any change in color of the solution is noted. The inlet and outlet bends are of such length that the solution forms a liquid lute against the pressure of the gas in the apparatus.



APPARATUS FOR CONTINUOUS TESTING OF GAS

The indicator used is a solution of methyl red with sufficient acid added just to develop the true red color of the acid indicator. The color change from red to yellow (in alkaline solution) can be readily observed by artificial light. Complete absorption of ammonia takes place with a flow of gas through a 2-mm. diameter jet (about 5 cu.ft. per minute), and with the indicator solution set at a fast dropping rate a very sensitive indication can be obtained.

The apparatus is used qualitatively, but with suitable calibration it might be employed for approximate quantitative estimation. It is suggested that a similar form of apparatus might be conveniently used for other purposes, for example the detection of acid vapors in chimney gases. But it can only be used where colorimetric tests can be applied owing to the fouling of the observation tube by anything in the nature of an adherent precipitate. Another possible application is for the detection of CO using the iodine pentoxide method in which the iodine liberated is absorbed by a continuous stream of potassium iodide solution to which are added a few drops of starch solution as an indicator. The arrangement as shown is made especially to obviate siphoning of the entering liquid, though under certain conditions siphoning at intervals might be a distinct advantage.

Mechanical, Micrographic and Macrographic Properties of Alloys High in Zinc.—MESSRS. LEON GUILLET and VICTOR BERNARD have studied mechanically, micrographically and macrographically the alloys high in zinc (*Revue de Metallurgie*, 15, No. 5, Sept.-Oct., 1918). Their aims were: 1. To determine the influence of copper and aluminium on the properties of zinc. 2. To examine some ternary alloys Zn-Cu-Al. 3. To study

the variation of the properties of the alloys with temperature, and to determine the temperature optimum for their forging and working.

A. The results of the mechanical tests are summarized as follows:

According to the purity of the zinc, and especially with its content of lead, the mechanical properties of rolled zinc are:

Breaking strain $R = 15$ to 16 kg.
Extension $A = 35$ to 47 per cent

The cast alloys do not present any interesting feature. An alloy with 8 per cent copper has a breaking strain of 17 kg., but the elongation and resilience are nil. A rolled alloy of 3 per cent aluminium has a breaking strain of 23 kg. and an elongation of 15 per cent. A rolled alloy of 2 per cent aluminium and 3.6 per cent copper has a breaking strain of 32 kg. and an elongation of 5 per cent. When drawn down the alloys generally show a higher breaking strain and a greatly increased elongation. Thus:

Alloys		Breaking Strain R	Elongation, Per Cent A	Resilience S
2.5 per cent Al	Rolled	22.0	4.4	1.2
	Drawn	25.9	26.4	2.5
1.3 per cent Cu	Rolled	23.0	1.5	1.8
	Drawn	30.5	27.9	1.9
4.2 per cent Cu	Rolled	30.5	7.3	1.2
	Drawn	33.5	22.0	1.6
2.1 per cent Al, 3.6 per cent Cu	Rolled	32.1	4.4	1.2
	Drawn	37.4	16.1	1.2

The drawn alloys possessing somewhat similar mechanical properties to drawn brass ($R = 28$ to 32 kg. $A = 30$ to 25 per cent, $S = 3$ to 5) are:

Alloy: Ordinary zinc (1 to 1.2 per cent Pb) 97.5 per cent to 98 per cent, copper 1.5 per cent to 2 per cent with $R = 30$ to 31 kg., $A = 27$ to 28 per cent, $S = 2$.

Alloy: Ordinary zinc (1 to 1.2 per cent Pb) 88 per cent, copper 4 per cent, aluminium 8 per cent with $R = 36$ kg., $A = 24$ per cent, $S = 1.2$. It is to be noted that the resilience of these alloys is much smaller than that of brass.

B. The results of the micrographic examinations are summarized as follows:

Zinc-aluminium alloys. These two metals form two solid solutions, one containing 0 to 4 per cent Al and the second from 50 to 100 per cent Al. These two solutions form a eutectic which corresponds to 5 per cent Al. It has been found that a eutectic is formed in an alloy with only 1 per cent Al. This is probably due to heterogeneity of the alloy.

Zinc-copper alloys. In these alloys there is a solid solution η when the percentage of copper is at the most 2.5 and two solid solutions, one η and another ϵ, when the percentage of copper is between 2.5 and 13. The solution ϵ increases with the percentage of copper; it gives rise to brittleness and its formation should be avoided by limiting the percentage of copper.

Zinc-aluminium-copper alloys. A complete examination of the Zn-Al-Cu alloys has not yet been made, but it appears that the solid solutions of zinc with aluminium and of zinc with copper are formed independently. The constituent ϵ increases with the percentage of copper, the eutectic also increases. The properties of the alloys correspond with the separate properties of these solutions. This explains the remarkable properties of the alloy zinc 88 per cent, aluminium 8 per cent, copper 4 per cent, in which the eutectic of the two solutions predominates (to which correspond the properties $R = 27$ and $A = 27$ per cent) and a certain quantity of ϵ which increases the hardness.

C. The results of the macrographic examinations are summarized as follows:

1. In cast samples the macrographic examination reveals large elongated crystals. The constituents observed in the micrographical examination are generally visible and sometimes distributed heterogeneously. 2. In rolled samples the crystal structure is not apparent, but the heterogeneity is often revealed. 3. In drawn samples the transverse as well as the longitudinal sections show defaults of homegeneity in the center. They cannot be eliminated by annealing. This point deserves careful consideration. The mechanical properties of the alloys vary with the temperature, the elasticity increasing very rapidly between 100 deg. C. and 150 deg. C. The optimum temperature for forging and working the alloys is 125 to 130 deg. C.

The conclusion is that of all the alloys high in zinc only two deserve special attention, namely:

Alloy: Ordinary zinc 98 per cent, copper 2 per cent, with $R = 30$, $A = 28$ per cent, $S = 1.9$.

Alloy: Ordinary zinc 88 per cent, copper 4 per cent, aluminium 8 per cent, with $R = 36$, $A = 24$ per cent, $S = 1.2$.

Electrometallurgical Treatment of Nickel Ores in New Caledonia.—The electrometallurgical treatment of the New Caledonia nickel ores has not given satisfactory results until lately in regard to the production of a ferronickel low in carbon and silicon. Mr. M. SABATHIER gives in the *Journal du Four Electrique*, 28, No. 1, Jan. 1, 1919, the method used at Taô, on the eastern coast of New Caledonia, for treating garnierite in an electric furnace, by which he obtained a product containing less than 0.5 per cent carbon and about 0.2 per cent silicon.

The ore treated is a garnierite of the following composition:

	Per Cent		Per Cent
SiO_2	53.10	Al_2O_3	0.50
NiO	6.62	CaO	1.70
	(5.20 Ni)	MgO	15.30
Fe_2O_3	12.68	Loss on ignition	9.90
	(8.85 Fe)		99.80

The principle of the method is to heat the ore with carbon, whereby the total nickel oxide and part of the iron oxide are reduced; the non-reduced iron oxide becomes a part of the slag, while the reduction of silica is avoided by the use of lime giving a basic slag. The charge is composed of:

(a) Run of mine ore, which contains 20 to 25 per cent moisture.

(b) Powdered charcoal in a well-defined porportion to reduce the total nickel oxide and part of the iron oxide.

(c) Lime in proportions to give a basic slag.

A 400-kw. furnace is used. Two electrodes are used which are in series. The product obtained is a ferronickel of 50 per cent Ni with a maximum of 0.5 per cent C (the usual percentage being about 0.05 per cent C) and about 0.2 per cent silicon.

The electric energy consumed per ton of ferronickel 50 per cent Ni is 13,000 kw.-hr., with electrode consumption of 125 kg. There is a 2 to 3 per cent loss of nickel in the slag. When producing a ferronickel of 75 per cent Ni the carbon percentage is even smaller than for the 50 per cent Ni ferronickel, the percentage of silicon is the same, which is about 0.2 per cent, but the loss of nickel in the slag is 4 to 5 per cent of the total nickel in the charge.

Recent Chemical and Metallurgical Patents

Briquetting Brittle Metals.—F. A. VOGEL of New York City notes that the Ronay system of briquetting operates very well on many metals, but does not press brittle borings into a coherent mass. The Ronay process operates in such a manner as to cause attrition between contiguous metallic surfaces under conditions which exclude air or other film. Molecular cohesion then seems to unify the particles into almost an integral mass. Borings or turnings of steel are usually covered with oil, soap or other foreign matter which tends to prevent such particles from coming into direct contact. Brittle borings are, therefore, first reduced in size by grinding in an edge runner and then heated to a point which not only will burn any carbanaceous foreign material, but also after a slow cooling will bring the particles into a dead-soft anneal. Thereupon such metallic particles can be made into coherent briquets by the Ronay system. (1,299,878; assigned to General Briquetting Co., Apr. 8, 1919.)

Zinc Leaching.—H. L. SULMAN and H. F. K. PICARD of London, England, note that in the leaching of oxidized or roasted zinc ore with sulphuric acid it is extremely difficult to neutralize the last amounts of free acid solely by agitation with ore. They, therefore, propose to start with a solution containing approximately 10 per cent of sulphuric acid, and when the free acid has been reduced to from 1 to 2 per cent by successive additions of ore, the neutralization is completed by zinc hydrate. This pulp is then agitated at a high temperature to precipitate soluble silica in granular form when the zinc solution is separated from the various insolubles by filtering in the ordinary way. The filter cake still contains considerable soluble zinc which is removed by wash water—this wash water, however, is not added to the original solution, but is agitated with milk of lime. In this manner zinc hydrate and calcium sulphate are precipitated from the solution and are used as above noted to neutralize residual acidity in the leaching solution. (1,295,080; assigned to the Metals Extraction Corporation, Ltd., of London, England, Feb. 18, 1919.

High-Phosphorus Slag.—WILLIAM R. WALKER of New York City notes that American iron ores are so low in phosphorus that when the resulting pig iron is refined, the resulting slag is very low in phosphates, owing to the fact that so much lime must be added to flux the silicon. In order to produce phosphate slag containing at least 13 per cent of soluble phosphates, he first treats the iron in an acid bessemer converter. Here the silicon is reduced to small traces and the skimmed metal then transferred to a refining furnace, such as an open-hearth or an electric furnace. A basic slag is then made up which rapidly absorbs phosphorus from the bath. When the slag contains the greater part of the phosphorus, as much of it is withdrawn as is convenient and a second or finishing slag is added to complete the refining operation. The first slag may contain upward of 18 per cent phosphate, soluble in citric, and is therefore available as a fertilizer. The second slag is relatively low in phosphorus, but is high enough in calcium and iron so that it can be recharged in a blast furnace, thus recovering its phosphorus. (1,299,072; Apr. 1, 1919.)

Hardening-Machine.—C. C. JACKMAN and R. S. SQUIRE of Springfield, Mass., have patented a hardening machine especially adapted for the treatment of continuous objects such as wire or other long narrow objects which can be linked together in a continuous chain. During hardening such a chain is passed

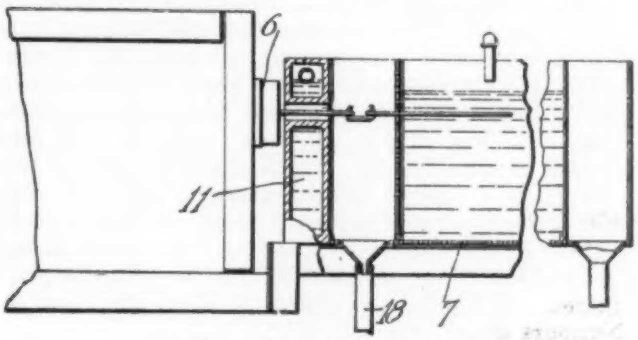
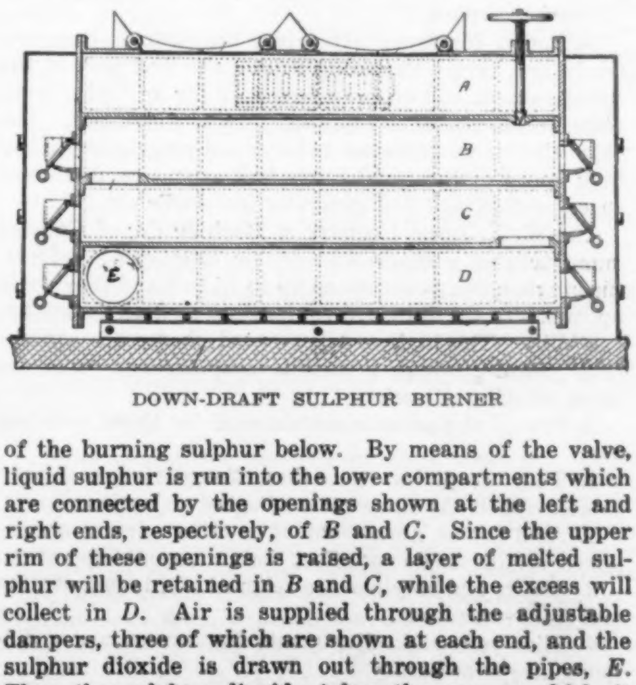


FIG. 1. HARDENING MACHINE

through an annular heating furnace of correct design, and on emerging from the furnace at 6 (Fig. 1) passes directly into the quenching tank 7. The quenching oil necessarily flows out of the tank through the slot by which the heated metal enters. Such oil is drained off through pipe 18, but the spray thrown up by this spashing oil has in the past quite often caught fire from the red-hot furnace, with disastrous results. The inventors, therefore, interpose between quenching tank and furnace the water-cooled jacket 11, which effectually prevents such fires. (1,299,949; assigned to Massachusetts Saw Works, Apr. 8, 1919.)

Down-Draft Sulphur Burner.—The burner shown in the accompanying illustration consists of four chambers, *A, B, C, D*. The uppermost, *A*, serves as a supply chamber for the sulphur, which is melted by the heat



DOWN-DRAFT SULPHUR BURNER

of the burning sulphur below. By means of the valve, liquid sulphur is run into the lower compartments which are connected by the openings shown at the left and right ends, respectively, of *B* and *C*. Since the upper rim of these openings is raised, a layer of melted sulphur will be retained in *B* and *C*, while the excess will collect in *D*. Air is supplied through the adjustable dampers, three of which are shown at each end, and the sulphur dioxide is drawn out through the pipes, *E*. Thus the sulphur dioxide takes the course which it would naturally pursue, since it is heavier than air. The whole furnace is surrounded by a jacket having sliding

dampers (shown in dotted lines in the center of *A*) through which the air supply must pass while the burner is in operation, the object being to preheat the air by contact with the hot walls. Numerous peepholes are provided so that the color of the flame may be observed and the air regulated accordingly. It is claimed that sublimation is avoided by this construction. (1,303,-348; AINWELL G. MCINTYRE; May 13, 1919.)

Aniline Hydrochloride.—Since aniline hydrochloride is less soluble than aniline in benzene, toluene, carbon tetrachloride and similar solvents, the hydrochloride is obtained as a pure white precipitate when dry hydrogen chloride is passed into or over a solution of aniline in any of these solvents. CHARLES AHLUM of Chester, Pa., claims that this process not only gives a lighter colored product, but also obviates the necessity of repeated filtrations and concentrations, with their accompanying losses due to decomposition of the salt and the frequent handling required. (1,303,624; assigned to E. I. du Pont de Nemours & Co.; May 13, 1919.)

Spur Gear Speed Reducer

GEAR speed reducers are being employed extensively for driving elevators, conveyors, driers, pumps, agitators, mixers, screens and many other classes of machinery where it is customary to use a considerable reduction in speed between the motor and driven unit. They have also found a useful application and have rapidly gained favor for line-shaft service. On many belt-driven line-shaft installations, the main line drive pulley is nearly double the size of any other pulley on the shaft, which makes it necessary to provide hangers of sufficient depth to clear the drive pulley, while if a gear speed reducer were used it would be possible to use shorter hangers throughout the entire length of the line shaft, thus making an initial saving, besides providing a much more rigid drive as well as effecting a saving in overhead space.

Although for line-shaft drives the ratio is comparatively low, rarely exceeding 9 to 1, the first cost of the speed reducer will often be less than for any other complete drive, taking everything into consideration. Besides this, it will frequently be found practicable to use high speed motors, which are less expensive than slow speed motors and are generally more efficient.

The W. A. Jones Foundry & Machine Co. of Chicago manufactures a single and double type speed reducer, the single having reductions up to 15 to 1 and the double up to 200 to 1. Standard equipments as high as 200 hp. are built. The high and low speed shafts are concentric, joined through a flexible coupling and have the same rotating direction.

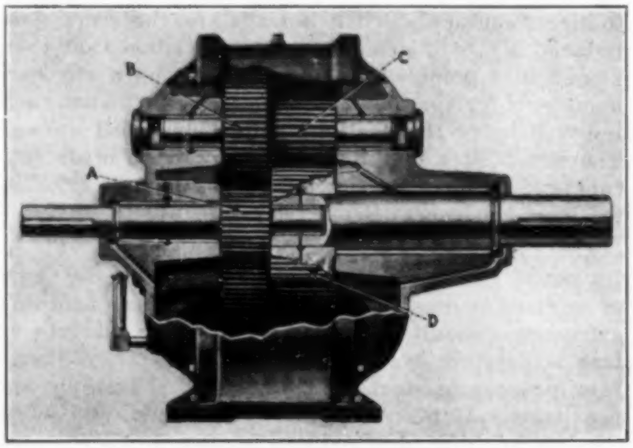
A few of the advantages claimed for these reducers are:

1. They occupy less space than other devices necessary to accomplish the same ratio of speed reduction.
2. Acid fumes, abrasive dust or other adverse atmospheric conditions do not affect their successful operation.
3. Shafts and bearings are relieved of all cross strains and transverse loads.
4. Slide rails and adjustments for correct center distances are unnecessary.
5. They require practically no attention and are quiet, efficient and durable.
6. The decrease installation costs.
7. All safety laws are complied with: There are no exposed moving parts that will cause injury to workmen.

Referring to the accompanying illustration, it will be seen that the pinion *A* meshes with and drives the three gears *B* which are mounted integral with the three pinions *C*. These in turn mesh and drive the slow speed gear *D*.

The gears *B* and pinions *C* are equally spaced around the high and slow speed pinion and gear at angles of 120 degrees, thus relieving both high and slow speed shafts and bearings of all transverse loads due to tooth thrust.

The high speed shaft and pinion *A* are forged from one piece of special analysis nickel steel. The pinion *A* is amply supported in correct alignment at one end by the bronze bushed bearing in the reducer housing,



SPUR GEAR SPEED REDUCER

and on the other end by the slow speed shaft extension which carries a bushed bearing.

All gears and pinions are finished from steel forgings, the accurately generated teeth being of the involute stub form with 20 deg. pressure angle, which insures great strength, maximum efficiency and long life. All shafts are accurately ground to size and are supported in heavy bronze bushed bearings, which insures correct alignment and proper meshing of the gear teeth. The splash system of lubrication automatically insures a copious supply of lubricant at all times.

Personal

MR. WALTER ARTHUR, formerly chief chemist and metallurgist with the Garfield Motor Truck Co., Lima, Ohio, has accepted a similar position with the Haynes Automobile Co., Kokomo, Ind.

MR. C. D. BALL, JR., has been discharged from the Chemical Warfare Service and resumed his duties as instructor in chemistry at the Michigan Agricultural College, East Lansing, Mich.

MR. RALPH V. DAVIES is now in the technical control department of the Aluminum Co. of America, New Kensington, Pa.

MR. F. W. DEARBORN, formerly of the Ordnance Department, is now on the staff of the Bureau of Standards, where he will be engaged especially in research on the chemistry of cellulose.

MR. JOHN T. FULLER has accepted a position with the American Bauxite Co., Bauxite, Ark.

DR. JOHN A. MATHEWS, president of the Halcomb Steel Co., Syracuse, N. Y., sailed for Europe recently as a member of the War Department's Aircraft Standardization Committee, headed by Assistant Secretary Crowell, to study the standardization in aircraft building in Europe.

MR. H. W. MORSE gave an illustrated talk before the San Francisco section of the American Chemical Society on May 19 on the manufacture of potash and borax at Searles Lake, California.

MR. FLOYD W. PARSONS has resigned as editor of *Coal Age* to accept a position with the *Saturday Evening Post* as head of the business and science department.

MR. S. F. SHAW has accepted a position as superintendent of the Charcas Unit, National Metallurgical Co., Charcas, Mexico.

DR. WILLIAM H. WALKER has received his discharge from the United States Army and is returning to civil life at his home in Bridgton, Me. Dr. Walker was commissioned Colonel in the Chemical Warfare Service and had charge of the Edgewood Arsenal.

PROF. WATURO WATANABE has retired from the post of professor of mining and metallurgy, as well as the director of the Engineering College, and has been elected emeritus professor of the Imperial University, Tokyo, Japan.

MR. ROBERT E. WILSON has accepted a position as assistant director of the research laboratory of applied chemistry and assistant professor of chemical engineering in the Massachusetts Institute of Technology, Cambridge, Mass.

MR. LOUIS E. WISE, formerly of the Bureau of Chemistry, has resigned to accept a position with E. I. du Pont de Nemours & Co., Wilmington, Del., as organic research chemist.

MR. HARRY J. WOLF has resigned his position as professor of mining, Colorado School of Mines, to accept a position on the editorial staff of the *Engineering and Mining Journal*.

A State Bureau of Mines at Butte has been organized with MR. C. H. CLAPP as director and geologist, MR. H. B. PULSIFER as metallurgist and MR. A. E. ADAMI in charge of the department of mining engineering.

Current Market Reports

The Non-Ferrous Metal Market

Tuesday, June 10.—Prices have taken a firm tone. Copper appears to have gained its normal market equilibrium and will probably not fluctuate much above or below 17½c. in the near future.

Aluminium:—A good volume of business is reported at 33c. per lb. on 98-99 per cent ingots. Scrap sales are reported as follows: Cast, 20-23c.; sheet, 20-23c.; clippings, 22½-26c. Sheets 18 gage and heavier, 42c. Powder, $0.70-1.40 lb.

Antimony:—There is a slight shortage in antimony supplies, wholesale spot bringing 8¾c. and future 8-8½c. lb. Job lots, 8⅝c. lb.

Copper:—The advance in copper has settled at 17⅝-17½c. lb. with no lower offers on futures. Scrap is bringing from 12 to 16c.

Copper sheets, hot-rolled	lb.	$0.24 —	.....
Copper sheets, cold rolled	lb.	.25 —	.....
Copper bottoms	lb.	.23½—	.....
Copper rods	lb.	.21 —	.....
Copper wire	lb.	.18 —	$0.18½
High brass wire and sheets	lb.	.19¼—	.....
High brass rods	lb.	.18¾—	.....
Low brass wire and sheets	lb.	.21¼—	.....
Low brass rods	lb.	.22¼—	.....
Brazed brass tubing	lb.	.30¼—	.....
Brazed bronze tubing	lb.	.35 —	.....
Seamless copper tubing	lb.	.29 —	.....
Seamless bronze tubing	lb.	.35 —	.....
Seamless brass tubing	lb.	.30 —	.....
Bronze (gold) powder	lb.	1.00 —	.....

Lead:—Lead is very stable. New York asks 5¼c. and E. St. Louis 5c. lb. Sheet lead has advanced to 8½c. lb.

Tin:—A complete liquidation of the 72½c. tin allocation is expected in the fore part of July.

Zinc:—Spelter has had a slight rise in New York, to 6⅝c., with futures up to 6¾c.; E. St. Louis, 6½c. with August futures at 6½c.

OTHER METALS

Bismuth	lb.	$3.20 —	$3.65
Cadmium	lb.	1.40 —	.....
Cobalt	lb.	2.50 —	3.50
Magnesium	lb.	1.75 —	2.10
Mercury	75 lb.	92.00 —	.....
Nickel	lb.	.40 —	.45
Iridium	oz.	175.00 —	.....
Palladium	oz.	115.00 —	120.00
Platinum	oz.	105.00 —	.....
Silver	oz.	1.10⅝—	.....

The Iron and Steel Market

The improvement in steel demand that began May 10 or 15 and made good progress during the second half of the month gained only a little additional headway during the first half of June. There was no retrogression, however, in any branch of the finished steel trade, and demand for some products, particularly sheets and merchant steel pipe, increased very considerably.

It is the common opinion that the movement has not gained sufficient momentum to carry it through what is normally the dull summer period. In recent years it was only in 1915 that there was a really active market in July and August, and in that year the foundation for the greatest rise in steel market history was being laid. Should the steel market become relatively dull in July and August, however, the probability would be of a fresh movement starting in early autumn of greater proportions than the one now being experienced.

PRODUCTION HEAVIER

Production of pig iron during the first half of June was at a rate of fully 25,000,000 tons per annum, or a rate slightly in excess of the rate in the latter part of May. Up to that time there had been a continuous decrease in pig iron production, but the turn seems to have occurred. High humidity in the midsummer period would decrease the rate of production as to the furnaces actually in blast, but such a decrease would be only a temporary and seasonal affair. Pig iron production at 25,000,000 tons a year means 58 per cent of capacity if capacity be taken at 43,000,000 tons a year, and 56 per cent if capacity be taken at 45,000,000 tons. The actual commercial capacity probably lies within these limits. Steel ingot production is at approximately the same percentage of capacity. In the early months of the year pig iron production was at a much higher proportionate rate to capacity than was shown by steel. It is probable that steel mills having blast-furnaces were endeavoring to liquidate stocks of ore, while steel mills using purchased pig iron were endeavoring to work out contracts, thus using more than usual proportions of pig iron. With conditions fairly well liquidated in this respect, there is probably heavier consumption of scrap in steel making than formerly. Earlier in the year heavy melting steel scrap touched a low point of about $14.50, delivered Chicago, Pittsburgh or Philadelphia, there being scarcely any demand. At the beginning of June the market was approximately $16, and in the fore part of the month the Pittsburgh market advanced to $17. Scrap dealers describe the market as dull, but there has probably been quite heavy absorption of scrap, both by direct purchases of mills from railroads and other producers and by purchases of Government scrap lying in the mills' own yards.

CHARACTER OF DEMAND

Those who doubt whether the steel trade can become really active until there is a radical change in conditions point to the fact that there is no railroad buying, and not likely to be any for deliveries this side of next spring, and also urge that there is little new construction work being undertaken, while railroad demand and general construction work always absorb much more than half the steel output when there is production at capacity. The theory seems plausible enough at first glance, but when one takes notice of the fact that the mills have been operating at 55 per cent or more of capacity he wonders how that can occur if more than half the steel demand is missing. When the operating rate is 55 per cent, the more customers there

are who are out of the market the better, for at some time or other they would have to come in, and there might not be room for them. The probability is that a fair amount of construction work is in progress despite the general appearance of dullness in that direction.

A factor in the present steel situation should be noted, that while in ordinary periods of activity there is well distributed demand from all quarters, the period of activity upon which the steel trade must enter at one time or another represents an accumulation of demand and it is not necessary that all classes of consumers should be equally active throughout this period of activity. Some consumers may fill the major portion of their accumulated requirements in a short time, others may buy little in the near future but a great deal more in the later future.

Steel Prices

It is a question whether there is more or less shading of steel prices now than there was before the recent increase in activity. The demand is not heavy enough to firm up prices, while when there is more inquiry there is more temptation to cut prices. Where there is shading, however, it rarely amounts to more than from \$1 to \$4 a ton, and the general foundation of the market is much firmer in this respect, that the cutting does not precipitate a break. Earlier in the year it was the feeling of many if not all steel producers that any yielding in the market would precipitate not merely a decline but a serious break. The whole bottom might drop out of the market. Nothing of the sort is now feared. The market is standing more or less on its own feet.

Pig Iron

Technically there has been an open market in pig iron since about April 1. It has been necessary for pig iron to adjust itself to commercial conditions, for the war-time price structure was altogether artificial. The normal condition is for pig iron to sell at higher prices in some producing districts than in others, according to variations in cost of production and the amount of pig iron that can be disposed of within a certain freight radius. Birmingham iron, for instance, has always had to penetrate into Northern markets and compete with Northern furnaces, and thus prices f.o.b. Birmingham were always lower than prices f.o.b. Chicago, Ironton, eastern Pennsylvania and other furnaces. The war control, however, gave Birmingham the full f.o.b. furnace basis. The \$3 reduction in December, 1918, and the \$4.25 reduction proclaimed as effective March 21 did not touch the war-time basings. Birmingham iron has now declined so as to be more or less competitive with Northern iron. The March 21 price on foundry iron 1.75 to 2.25 per cent silicon was \$26.75, while Birmingham iron is now available at \$23.50, furnace. Some of the Lake front furnaces have cut prices in order to sell in distant markets, while endeavoring to hold prices as to their own local markets, and the same is true of southern Ohio furnaces. Taking the pig iron market as a whole, however, the decline has been very slight and it is quite improbable that there will be any large decline in the near future. The merchant furnaces have met the situation of light demand by blowing out. Predictions are beginning to be made of advances for pig iron in the near future, but such predictions are not in keeping with market history. When there are many furnaces out the pig iron market experiences the greatest difficulty in scoring an actual advance. At successive intervals idle furnaces come into blast, each furnace first selling some pig iron at any price obtainable to furnish the desired "back log."

General Chemicals

New York, June 9, 1919.

The firmer tendency noticeable is due in great part to the increasing influence of manufacturers. Many chemicals which have been selling in second hands at a figure far below the present cost of production are now entirely absorbed, leaving manufacturers largely in control of the situation. Particularly is this true of caustic soda, soda ash, bleaching powder and barium carbonate. Export inquiries continue in good volume. Spain, Denmark and South America show particularly satisfactory developments in this respect.

Large shipments of caustic soda continue to be made, Japan and South America being the heaviest buyers. This steady demand has absorbed material in second hands with a resulting stronger market. Acetic acid shows a decline, manufacturers having reduced their schedules to stimulate sales. Citric acid holds a much stronger position due to the recent warm weather and the consequent extra demand in the face of limited supplies.

Muriatic, sulphuric and nitric acids are receiving a good demand. Much of the muriatic is being shipped to Cuban sugar manufacturers, while the call for sulphuric comes chiefly from South America. Excess supply has caused pyrogallic to drop, being quoted now around \$2.40 a pound.

Although most dealers have advanced slightly the price of bleach, there being no surplus stocks, one dealer is offering a lot of forty carloads at the low figure of \$1.25 a cwt., New York.

Potassium carbonate shows an inclination to advance, some dealers having already jumped the price owing to demand from Denmark. Caustic potash remains unchanged, but is likely at any time to move in sympathy with potassium carbonate. Most of the potash products, however, are weak, owing to heavy competition with foreign goods.

When the Government relinquishes control of the price of sodium nitrate, on July 1, importers anticipate a reduction to \$3.10 a cwt. from the present figure of \$4.07½.

Coal-Tar Products:—The demand for crudes has increased during the interim and is confined almost entirely to domestic users. Benzol is particularly active with production cut. The price on pure water white is now 24-28c. per gal., the 90 per cent grade, 23½-27c. There will be little available spot stock of benzol until the close of July. Competition with the English product has caused a cut in cresylic acid.

The tendency on the part of intermediates to pick up, noted several weeks ago, continues and some manufacturers find difficulty in keeping up with the demand for some of the intermediates. The textile mills are beginning to consume dyes, with the result that dyemakers are increasing their demands for the coal-tar intermediates. Those receiving the heaviest call are alpha-naphthylamine, paratoluidine, paranitrotoluol and aniline oil. One manufacturer reports his entire output of paratoluidine promised to July on orders.

Waxes:—Most waxes have advanced in price. Spot stocks have been cleaned out with the result that offerings for shipment are light and the market is firm for futures.

Beeswax owes its advance to unprecedented demand and the limited arrivals of stock. The same with Japan wax.

A firm market in Brazil in conjunction with continued heavy demand here, in the face of a scanty supply, are the contributing factors in the jump of carnauba.

Although paraffine waxes have dropped still further in price, there is slight tendency toward a firmer tone. The difficulty with this commodity is that the demand by no means equals the production. However, it is believed that this condition will be overcome in a short time. A favorable sign is the increasing number of inquiries now coming from South America. Previously, the greater number of inquiries were from Europe. The demand from that source continues to hold fairly strong, while the domestic call is fair.

The recent warm weather has affected the production of stearic acid, causing an advance.

Oils: — Unabated European demand has continued to strengthen vegetable oils. England continues her heavy buying, with Sweden a close second. Domestic buyers are coming into the market for large quantities, apparently realizing that because of the huge export demand prices will undergo no reduction for some time.

There appears to be not so much a shortage of oils as that they are held in strong hands. This is attested to by the fact that several consignments of oils (part of the allocations made by the Government for Europe several weeks ago) were cancelled owing to late arrival at the docks and are now being held by the shippers. It is pre-

dicted, however, in some quarters that a scarcity may eventually be felt. For if England persists in her demand producers in the Orient will be likely to divert their supplies to the British market, thus forcing dealers here to rely on domestic crops, which may or may not meet the demand.

The expected advance in linseed oil has materialized and most dealers have increased previous quotations by three cents. The main factor in this condition is the scarcity of seeds and, in addition, dock strikes in Argentina have held up shipments of seed.

Of considerable interest to the local trade is the recent announcement by the Spanish government of an embargo on the export of olive oil during the present month due to shortage.

It is the belief of many dealers that this regulation will continue in effect throughout the summer. With present supplies of olive oil none too plentiful, an advance is anticipated shortly.

Decreasing stocks due to heavy demand and the fact that catches of oil producing fish are below normal and the fish less fat than last year offer the chief basis for the rising market on fish oils. Crude fish oils in particular are receiving a heavy call from Europe. England is now asking for 5000 bbl. of crude menhaden oil, without response, because producers are unwilling to hold the oil until shipping space can be obtained.

On the domestic side, with the leather, steel and paint industries gradually increasing production, the buying in these quarters is increasing in volume.

SHELLAC:—There is no noteworthy change in the shellac situation. Now and then a few bags appear on the market but are quickly bought up. Sales of a few packages of V. S. O. at $1.15 were reported this week, with dealers asking 90c. for orange superfine, and 80c. for A.C. garnet grade; bleached, bone dry is held at an even $1.00. No T.N. or D.C. is offered and the other grades in only a very limited quantity.

Although there were fairly heavy arrivals from Calcutta last week, the entire amount went to fill old orders. The arrival of the May steamers from Calcutta is expected within the next six weeks, but these shipments will likewise go to cover previous sales.

Contrary to earlier reports, information comes now that supplies in Calcutta are not as plentiful as was anticipated. It appears unlikely that the situation will be relieved before fall.

NAVAL STORES:—Eight years ago spirits of turpentine attained the high mark of $1.19 per gal. Following a daily advance, the price at this writing is $1.04-1.06, with indications of a further jump. Continued heavy demand from abroad with strong domestic buying is given as the reason. London is reported the heaviest buyer. Nearly all the old stocks have been sold and the South is being given no opportunity to accumulate stocks. There is practically no spot material to be found in New York.

St. Louis, Mo., June 9.

A decided increase in demand for certain of the heavy chemicals, particularly sulphuric acid, is reported by local producers. With this development, naturally, has come a firmer feeling and in some cases appreciable price advances.

The fact that the contract renewal season is close at hand explains the increasing number of inquiries. A good deal of spot business is being consummated, however. While much of the trading in heavy chemicals on the mid-West market still gives signs of mere hand-to-mouth buying, the feeling also is creeping in that prices in most branches of the market have reached the bottom and that henceforth any fluctuations will have an upward tendency.

In the lines where higher prices are being asked than was the case a fortnight ago, buyers are reluctant to meet the advance and the market has developed an endurance test between buyers and sellers. Sales are reported at the higher prices, though admittedly few, but the interest in the market at the range of a week or two ago is keener and the general tone of the St. Louis market is firmer.

SULPHURIC ACID:—The demand for this chemical is characterized as very strong, especially from the fertilizer manufacturers. These interests have held aloof from the market for some time, awaiting the traditional "good time to buy." Indications are that they consider that time here or close at hand, for both orders and bona fide inquiries are reported more numerous and involving greater tonnage than has been the case for many months. The 60 per cent grade is now quoted at $12.50 to $14, according to quantity; 66 per cent sulphuric acid is held at $18 a ton. The higher degree of this acid, oleum, is quoted at $25 a ton and is reported in good demand on the part of dye and explosives interests. It is understood here that the increasing scope of operations in the oil well fields has produced a strong demand for torpedoes which in turn is being reflected in the sales of sulphuric acid.

MURIATIC ACID:—A satisfactory amount of business is being transacted in this line, producers claim. The price is stationary at $22 a ton for the 18 per cent grade, but is more firm than was the case a few weeks ago.

SODIUM SULPHATE (Salt Cake):—Greater activity is reported in this branch of the market, too, with prices varying between $19 and $20 a ton.

SODIUM BISULPHATE (Niter Cake):—Business in this department is reported slightly improved, some deals having been transacted at $4 to $5 a ton.

NITRIC ACID:—The market for this chemical is not showing great activity, the prevailing quotation for 38 Baumé being 10 @ 10½c. per pound.

ZINC CHLORIDE:—The demand for this product from the manufacturers of creosoting oils continues unabated, due to the heavy Government orders for railroad ties.

ZINC OXIDE:—An unusual situation is reported in the local zinc oxide market, namely, that for the first time in more than a year the market is extremely active during the period when the announcement of quarterly price changes is expected momentarily. Under ordinary conditions the weeks preceding the expected announcement of new prices are practically devoid of business. This week and last, however, heavy sales of zinc oxide both for domestic and foreign account are reported at 8 to 9c. per lb., according to lead sulphate contents, in carload lots and 8½ to 9½c. per lb. in less than carload lots.

Chicago, June 10.

Gradual improvement in local trade conditions which were noted last month are continuing as June advances, with no spectacular changes in any line except flotation oils. With gross sales for the month figuring up to a comfortable total, collections getting in better shape and a knowledge that overstock and second hands have been reduced to a point where manufacturing conditions have some bearing on prices, the outlook, from the jobbers' standpoint, is more favorable than it has been at any time since last November.

Inquiries are plentiful and sales are being made in reasonable quantity. As yet, however, no long term contracts are being made, jobbers themselves being disinclined to tie up for any great time on the basis of existing low prices.

With 66-deg. sulphuric holding at $20, with sales in normal quantities, practically the entire line of heavy chemicals remains very firm. Sodium hydroxide (caustic soda) is up about 30c., now selling at $2.80, while sodium bichromate, under light demand, has fallen a little, to 7¾c.

No appreciable changes have occurred in the coal-tar line, benzol still selling at 25c. A considerable market for benzol had developed in garage sales to auto owners, when benzol was cheaper than gasoline, but now that the price is higher, this selling has ceased. Commercial demands are sufficient to hold the price firm, however.

Vegetable oils remain very firm in price, with the market rapidly absorbing all offerings.

Two cents has been added to the price of the best grade of steam distilled pine oil, and turpentine has been imitating a rocket, the price on crude advancing 2 or 3c. every day for the past two weeks, and now ranging from $1.05 to $1.10. This has been caused by heavy demand and a stock on hand of only about one-third normal for this time of year. Jobbers are a unit, however, in believing present price to be too high, saying that 85 cents will probably be the figure at which it will ultimately rest.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET JUNE 9, 1919

Acetic anhydride	lb.	$0.52	—	$0.60
Acetone	lb.	.15	—	.15½
Acid, acetic, 28 per cent	cwt.	2.50	—	3.00
Acetic, 56 per cent	cwt.	5.50	—	6.00
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00	—	14.00
Boric, crystals	lb.	.13½	—	.14½
Boric, powder	lb.	.13¾	—	.14¼
Hydrochloric, tech. 20 deg	cwt.	1.50	—	3.00
Hydrofluoric, 52 deg	lb.	.10	—	.11
Lactic, 44 per cent. tech	lb.	.14	—	.17
Lactic, 22 per cent. tech	lb.	.05	—	.06
Molybdic, C. P.	lb.	4.50	—	5.50
Nitric, 40 deg	lb.	.07	—	.08
Nitric, 42 deg	lb.	.07	—	.08
Oxalic, crystals	lb.	.23	—	.28
Phosphoric, Ortho, 50 per cent. solution	lb.	.07½	—	.10
Picric	lb.	.30	—	.40
Pyrogallic, resublimed	lb.	2.45	—	2.55
Sulphuric, 60 deg., tank cars	ton	11.00	—	13.00
Sulphuric, 60 deg., drums	ton	17.00	—	.....
Sulphuric, 60 deg., carboys	ton	20.00	—	.....
Sulphuric, 66 deg., tank cars	ton	16.00	—	18.00
Sulphuric, 66 deg., drums	ton	21.00	—	.....
Sulphuric, 66 deg., carboys	ton	25.00	—	.....
Sulphuric, fuming, 20 per cent.(oleum) tank cars	ton	20.00	—	22.00
Sulphuric, fuming, 20 per cent.(oleum) drums	ton	25.00	—	.....
Sulphuric, fuming, 20 per cent.(oleum) carboys	ton	30.00	—	.....
Tannic, U. S. P.	lb.	1.30	—	1.40
Tannic (tech.)	lb.	.42	—	.60
Tartaric, crystals	lb.	.82	—	.85
Tungstic, per lb. of WO_3	lb.	1.20	—	1.40
Alcohol, Ethyl	gal.	4.00	—	4.85
Alcohol, Methyl	gal.	1.25	—	1.30
Alum, ammonia lump	lb.	.03½	—	.04½
Alum, potash lump	lb.	.08½	—	.10
Alum, chrome lump	lb.	.15	—	.....
Aluminium sulphate, commercial	lb.	.01¾	—	.03
Aluminium sulphate, iron free	lb.	.02½	—	.03
Aqua ammonia, 26 deg., carboys	lb.	.06½	—	.08
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.30	—	.....
Ammonium carbonate, powder	lb.	.12½	—	.13½
Ammonium chloride, granular(white salammoniac)	lb.	.13	—	.14
Ammonium chloride, granular(gray salammoniac)	lb.	.13	—	.14
Ammonium nitrate	lb.	.17	—	.20
Ammonium sulphate	lb.	.05½	—	.06
Amyl acetate	gal.	3.50	—	3.75
Arsenic, oxide, lumps	lb.	.09	—	.09½
Arsenic, sulphide, powdered	lb.	.30	—	.32
Barium chloride	ton	80.00	—	90.00
Barium dioxide (peroxide)	lb.	.19	—	.24
Barium nitrate	lb.	.10	—	.11
Barium sulphate (precip.) (blanc fixe)	lb.	.01½	—	.03
Bleaching powder (see calcium hypochlorite)		.....	—	.....
Blue Vitriol (see copper sulphate)		.....	—	.....
Borax (see sodium borate)		.....	—	.....
Brimstone (see sulphur, roll)		.....	—	.....
Bromine	lb.	.40	—	.50
Calcium acetate	lb.	.02	—	.02½
Calcium carbide	lb.	.05½	—	.06
Calcium chloride, fused, lump	ton	19.00	—	25.00
Calcium chloride, granulated	lb.	.01¾	—	.02
Calcium hypochlorite (bleaching powder)	cwt.	1.25	—	2.00
Calcium peroxide	lb.	1.50	—	1.70
Calcium phosphate, monobasic	lb.	.22	—	.23
Calcium sulphate, precipitated	lb.	.10	—	.20
Carbon bisulphide	lb.	.05½	—	.06
Carbon tetrachloride, drums	lb.	.11	—	.14
Carbonyl chloride (phosgene)	lb.	.75	—	1.00
Caustic potash (see potassium hydroxide)		.....	—	.....
Caustic soda (see sodium hydroxide)		.....	—	.....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05	—	.08
Cobalt oxide	lb.	1.60	—	1.65
Copperas (see iron sulphate)		.....	—	.....
Copper carbonate, green precipitate	lb.	.28	—	.31
Copper cyanide	lb.	.65	—	.70
Copper sulphate, crystals	lb.	.07	—	.08
Cream of tartar (see potassium bitartrate)		.....	—	.....
Epsom salt (see magnesium sulphate)		.....	—	.....
Formaldehyde, 40 per cent	lb.	.20	—	.21
Glauber's salt (see sodium sulphate)		.....	—	.....
Glycerine	lb.	.21	—	.23
Iodine, resublimed	lb.	4.25	—	4.30
Iron oxide, red	lb.	.03	—	.18
Iron sulphate (copperas)	cwt.	1.00	—	1.75
Lead acetate, normal	lb.	.12¾	—	.15
Lead arsenate (paste)	lb.	.15	—	.18
Lead nitrate, crystals	lb.	.85	—	.86½
Litharge	lb.	.09½	—	.10½
Lithium carbonate	lb.	1.50	—	.....
Magnesium carbonate, technical	lb.	.12	—	.14
Magnesium sulphate, U. S. P.	100 lb.	2.70	—	2.85
Magnesium sulphate, commercial	100 lb.	2.50	—	2.60
Nickel salt, double	lb.	.13	—	.15
Nickel salt, single	lb.	.11½	—	.14
Phosgene (see carbonyl chloride)		.....	—	.....
Phosphorus, red	lb.	.55	—	.65
Phosphorus, yellow	lb.	.26	—	.37
Potassium bichromate	lb.	.29	—	.33
Potassium bitartrate (cream of Tartar)	lb.	.52½	—	.55
Potassium bromide, granular	lb.	.49	—	.50
Potassium carbonate, U. S. P.	lb.	.65	—	.70
Potassium carbonate, crude	lb.	.11	—	.14
Potassium chlorate, crystals	lb.	.25	—	.31
Potassium cyanide, 98-99 per cent	lb.	Nominal		
Potassium hydroxide (caustic potash)	lb.	.35	—	.45
Potassium iodide	lb.	3.30	—	3.40
Potassium nitrate	lb.	.19	—	.22
Potassium permanganate	lb.	.60	—	.65
Potassium prussiate, red	lb.	.80	—	.95
Potassium prussiate, yellow	lb.	.27	—	.40
Potassium sulphate	ton	225.00	—	.....
Rochelle salts (see sodium potas. tartrate)		.....	—	.....
Salammoniac (see ammonium chloride)		.....	—	.....
Sal soda (see sodium carbonate)		.....	—	.....
Salt cake	ton	12.00	—	18.00
Silver cyanide	oz.	1.19	—	.....
Silver nitrate	oz.	.67	—	.69
Soda ash, light	100 lb.	$1.50	—	$1.75
Soda ash, dense	100 lb.	2.00	—	2.25
Sodium acetate	lb.	.06	—	.08
Sodium bicarbonate	100 lb.	2.25	—	2.50
Sodium bichromate	lb.	.07¾	—	.09
Sodium bisulphate (nitre cake)	ton	3.00	—	10.00
Sodium bisulphite	lb.	.05	—	.07
Sodium borate (borax)	lb.	.07½	—	.08
Sodium carbonate (sal soda)	100 lb.	1.30	—	1.60
Sodium chlorate	lb.	.15	—	.18
Sodium cyanide	lb.	.30	—	.31
Sodium fluoride	lb.	.14	—	.15
Sodium hydroxide (caustic soda)	100 lb.	2.50	—	2.75
Sodium molybdate	lb.	2.50	—	.....
Sodium nitrate	100 lb.	4.07½	—	.....
Sodium nitrite	lb.	.11	—	.13
Sodium peroxide, powdered	lb.	.25	—	.30
Sodium phosphate, dibasic	lb.	.04½	—	.05
Sodium potassium tartrate (Rochelle salts)	lb.	.43	—	.45½
Sodium prussiate, yellow	lb.	.17½	—	.20
Sodium silicate, solution (40 deg.)	lb.	.01¾	—	.02¼
Sodium silicate, solution (60 deg.)	lb.	.02¾	—	.04¾
Sodium sulphate, crystals (Glauber's salts)	cwt.	1.25	—	1.50
Sodium sulphide, crystal, 60-62 per cent (conc)	lb.	.04½	—	.05
Sodium sulphite, crystals	lb.	.03½	—	.04
Strontium nitrate, crystals	lb.	.25	—	.28
Sulphur chloride	lb.	.05	—	.05½
Sulphur, crude	ton	32.00	—	35.00
Sulphur dioxide, liquid, cylinders	lb.	.10	—	.12
Sulphur (sublimed), flowers	100 lb.	3.05	—	3.60
Sulphur, roll (brimstone)	100 lb.	2.70	—	3.15
Tin bichloride (stannous)	lb.	.22½	—	.25
Tin oxide	lb.	.60	—	.....
Zinc carbonate, precipitate	lb.	.18	—	.20
Zinc chloride, gran	lb.	.13½	—	.14
Zinc cyanide	lb.	.49	—	.50
Zinc dust	lb.	.09	—	.11
Zinc oxide, dry American	lb.	.09½	—	.11½
Zinc sulphate	lb.	.03¾	—	.04

Coal Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00	—	$1.10
Alpha naphthol, refined	lb.	1.40	—	1.50
Alpha naphthylamine	lb.	.40	—	.50
Aniline oil, drums extra	lb.	.22	—	.24
Aniline salts	lb.	.28	—	.33
Anthracene, 80% in drums (100 lb.)	lb.	.90	—	1.00
Benzaldehyde (f.f.c.)	lb.	1.00	—	1.15
Benzidine, base	lb.	1.00	—	1.15
Benzidine, sulphate	lb.	.90	—	1.10
Benzoic acid, U. S. P.	lb.	1.00	—	1.10
Benzoate of soda, U. S. P.	lb.	.95	—	1.10
Benzol, pure, water-white, in drums (100 lb.)	gal.	.24	—	.28
Benzol, 90%, in drums (100 lb.)	gal.	.23½	—	.27
Benzyl chloride, 95-97%, refined	lb.	.35	—	.40
Benzyl chloride, tech	lb.	.25	—	.35
Beta naphthol benzoate	lb.	4.00	—	4.50
Beta naphthol, sublimed	lb.	.75	—	.80
Beta naphthol, tech	lb.	.45	—	.55
Beta naphthylamine, sublimed	lb.	2.25	—	2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.18	—	.....
Ortho-cresol, in drums (100 lb.)	lb.	.23	—	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.85	—	.90
Cresylic acid, 95-97%, dark, in drums	gal.	.80	—	.85
Cresylic acid, 50%, first quality, drums	gal.	.60	—	.....
Dichlorbenzol	lb.	.07	—	.10
Diethylaniline	lb.	1.75	—	2.25
Dimethylaniline	lb.	.50	—	.57
Dinitrobenzol	lb.	.25	—	.30
Dinitroclorbenzol	lb.	.25	—	.28
Dinitronaphthaline	lb.	.45	—	.55
Dinitrotoluol	lb.	.38	—	.45
Dinitrophenol	lb.	.30	—	.32
Dip oil, 25% tar acids, car lots, in drums	gal.	.38	—	.46
Diphenylamine	lb.	.70	—	.75
H-acid	lb.	1.90	—	2.25
Metaphenylenediamine	lb.	1.20	—	1.80
Monochlorbenzol	lb.	.10	—	.14
Monoethylaniline	lb.	1.50	—	1.75
Naphthaline, crushed in bbls. (250 lb.)	lb.	.06	—	.08
Naphthaline, flake	lb.	.06½	—	.07½
Naphthaline, balls	lb.	.09¾	—	.10
Naphthionic acid, crude	lb.	1.00	—	1.25
Nitrobenzol	lb.	.13	—	.15
Nitro-naphthaline	lb.	.40	—	.45
Nitro-toluol	lb.	.17	—	.20
Ortho-amidophenol	lb.	6.00	—	.....
Ortho-dichlor-benzol	lb.	.15	—	.20
Ortho-nitro-phenol	lb.	1.25	—	.....
Ortho-toluidine	lb.	.40	—	.45
Ortho-nitro-toluol	lb.	.27	—	.40
Para-amidophenol, base	lb.	2.75	—	3.50
Para-amidophenol, H. Cl.	lb.	3.00	—	3.25
Para-dichlor-benzol	lb.	.06	—	.10
Paranitraniline	lb.	1.00	—	1.25
Para-nitro-toluol	lb.	1.35	—	1.50
Paraphenylenediamine	lb.	3.00	—	3.25
Para toluidine	lb.	1.50	—	1.75
Phthalic anhydride	lb.	1.75	—	2.15
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.08	—	.09
Pyridin	gal.	2.50	—	.....
Resorcin, technical	lb.	3.50	—	3.75
Resorcin, pure	lb.	6.50	—	7.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.20	—	.30
Salicylic acid, U. S. P.	lb.	.25	—	.35
Salol	lb.	.75	—	80
Solvent naphtha, water white, in drums, 100 gal.	gal.	.20	—	.25
Solvent naptha, crude, heavy, in drums, 100 gal.	gal.	.18	—	.20
Sulphanilic acid, crude	lb.	.25	—	.30
Tolidine	lb.	2.15	—	2.50
Toluidine, mixed	lb.	.45	—	.80
Toluol, in tank cars	gal.	.22	—	.24
Toluol, in drums	gal.	.23	—	.30
Xylidine, drums, 100 gal	lb.	.40	—	.45
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	.....
Xylol, commercial, in drums, 100 gal	gal.	.30	—	.40
Xylol, commercial, in tank cars	gal.	.30	—	.....

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.40	—	$0.43
Beeswax, refined, yellow	lb.	.45	—	.47
Beeswax, white pure	lb.	.62	—	.68
Carnauba, No. 1	lb.	.80	—	.85
Carnauba, No. 2, regular	lb.	.65	—	.72
Carnauba, No. 2, North Country	lb.	.55	—	.60
Carnauba, No. 3, North Country	lb.	.46	—	.48
Ceresin, yellow	lb.	.16	—	.18
Ceresin, white	lb.	.18	—	.20
Japan	lb.	.13	—	.19
Paraffine waxes, crude match wax (white) 105-110 m.p	lb.	.06	—	.07½
Paraffine waxes, crude scale, 117-119 m.p	lb.	.06	—	.07¾
Paraffine waxes, crude scale, 124-126 m.p	lb.	.07	—	.....
Paraffine waxes, refined, 118-120 m.p	lb.	.08¼	—	.08¾
Paraffine waxes, refined, 123-125 m.p	lb.	.08½	—	.09½
Paraffine waxes, refined, 128-130 m.p	lb.	.09½	—	.10
Paraffine waxes, refined, 130-132 m.p	lb.	.10¼	—	.11
Paraffine waxes, refined, 133-135 m.p	lb.	.11¼	—	.12
Paraffine waxes, refined, 135-137 m.p	lb.	.12½	—	.....
Stearic acid, single pressed	lb.	.18	—	.19
Stearic acid, double pressed	lb.	.20	—	.21
Stearic acid, triple pressed	lb.	.22	—	.24
Spermaceti	lb.	.30	—	.32

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$0.70
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.45
Pine tar oil, ref., sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.33
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.58
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.34
Turpentine, crude, sp. gr., 0.900-0.970	gal.	.61
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.24
Hardwood oil, f.o.b. Mich., sp. gr., 1.06-1.08	gal.	24
Pinewood creosote, ref	gal.	.48

Naval Stores

The following prices are f.o.b., New Nork, for carload lots.

Rosin B-D, bbl	280 lb.	$11.60	—	$12.25
Rosin E-I	280 lb.	12.20	—	12.45
Rosin K-N	280 lb.	14.10	—	14.45
Rosin W. G.-W. W	280 lb.	15.30	—	15.65
Wood rosin, bbl	280 lb.	11.95	—	......
Spirits of turpentine	gal.	1.04	—	1.06
Wood turpentine, steam dist	gal.	.90	—	......
Wood turpentine, dest. dist	gal.	.80	—	......
Pine tar pitch, bbl	200 lb.	8.00	—	8.25
Tar, kiln burned, bbl. (500 lb.)	bbl.	12.50	—	13.50
Retort tar, bbl	280 lb.	13.50	—	14.50
Rosin oil, first run	gal.	.68	—	.78
Rosin oil, second run	gal.	.70	—	.80
Rosin oil, third run	gal.	.82	—	.83
Rosin oil, fourth run	gal.	.85	—	.95

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Oils

VEGETABLE

Unless otherwise noted, the following prices are f.o.b., New York.

Castor oil, No. 3, in bbls	lb.	$0.19	—	$0.20
Castor oil, AA, in bbls	lb.	.21	—	.22
China wood oil, in bbls	lb.	.20	—	.22
Cocoanut oil, Ceylon grade, in bbls	lb.	.17	—	.17½
Cocoanut oil, Cochin grade, in bbls	lb.	.18½	—	.19½
Corn oil, crude, in bbls	lb.	.19½	—	.20½
Cottonseed oil, crude (f.o.b. mill)	lb.	.17½	—	.20
Cottonseed oil, summer yellow	lb.	.25	—	.26
Cottonseed oil, winter yellow	lb.	.26	—	.27
Linseed oil, raw, car lots	gal.	1.60	—	1.70
Linseed oil, raw, tank cars	gal.	1.52	—	1.56
Linseed oil, boiled, car lots	gal.	1.58	—	1.60
Olive oil, commercial	gal.	2.10	—	2.25
Palm, Lagos	lb.	.16½	—	.18
Palm, bright red	lb.	.16	—	.17
Palm, Niger	lb.	.15	—	.16
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.22	—	.23
Peanut oil, refined, in bbls	lb.	.26	—	.27
Rapeseed oil, refined in bbls	gal.	1.50	—	1.55
Rapeseed oil, blown, in bbls	gal.	1.58	—	1.60
Soya bean oil (Manchurian), in bbls., N. Y	lb.	.17½	—	.18
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.15¼	—	.15½

FISH

Winter pressed Menhaden	gal.	$0.90	—	$0.92
Yellow bleached Menhaden	gal.	.92	—	.93
White bleached Menhaden	gal.	.94	—	.95
Blown Menhaden	gal.	1.00	—	1.02

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$25.00	—	$36.00
Barytes, off color	ton	22.00	—	27.00
Blanc fixe, dry	lb.	.03½	—	.04½
Blanc fixe, pulp	ton	30.00	—	45.00
Casein	lb.	.16	—	.18
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.04½	—	.06
Chalk, English, dense	lb.	.04	—	.05
China clay (Kaolin), imported, lump	ton	35.00	—	......
China clay (Kaolin), imported, powdered	ton	60.00	—	......
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar	ton	11.00	—	15.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	$30.00	—	$35.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	35.00	—	40.00
Fuller's earth, domestic, powdered	ton	30.00	—	40.00
Fuller's earth, imported, powdered	ton	......	—	.....
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	.....
Shellac, TN	lb.	.60	—	.....
Shellac, D.C	lb.	.....	—	.....
Shellac, V. S. O	lb.	.....	—	.....
Shellac, Diamond I	lb.	.....	—	.....
Shellac, orange, fine	lb.	.73	—	.....
Shellac, orange, superfine	lb.	.75	—	.....
Shellac, A.C. garnet	lb.	.63	—	.....
Shellac, bleached, bone dry	lb.	.....	—	.....
Shellac, bleached, fresh ground	lb.	.....	—	.....
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	16.00	—	60.00
Talc, imported	ton	55.00	—	60.00

Refractories

Following prices are f. o. b. works:

Chrome brick	net ton	90–100 at Chester, Penn.
Chrome cement	net ton	45–50 at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	35–45 at Clearfield, Penn.
Clay brick, 2nd quality	net ton	30–35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50–55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in	net ton	80–90 at Chester, Penn.
Silica brick	net ton	41–45 at Mt. Union, Penn.

Ferro-alloys

All prices f. o. b. works.

Ferro-carbon-titanium, 15–18%, f.o.b. Niagara Falls, N. Y	net ton	$220.00	—	....
Ferro-chrome, per lb. of Cr. contained, 6–8% carbon	lb.	.32	—	$0.40
Ferro-chrome, per lb. of Cr. contained, 2–4% carbon	lb.	.70	—	....
Ferro-manganese, 70-80% Mn	gross ton	100.00	—	125.00
Spiegeleisen, 16-20% Mn	gross ton	40.00	—	50.00
Ferro-molybdenum, per lb. of Mo	lb.	2.50	—	3.00
Ferro-silicon, 50%	gross ton	90.00	—	115.00
Ferro-silicon, 75%	gross ton	150.00	—	175.00
Ferro-silicon, 10–15%	gross ton	45.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	1.30	—	1.60
Ferro-uranium, 35-50%, of U	lb.	7.00	—	......
Ferro-vanadium, 30-40%, per lb. of contained V.	lb.	5.50	—	7.00

Resales and overstocks make above prices approximate.

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.70		
Chrome ore, 48% and over	unit	1.00	—	$1.25
Coke, foundry, f.o.b. mines	net ton	4.50	—	5.00
Coke, furnace, f.o.b. mines	net ton	4.00	—	5.00
Petroleum coke, f.o.b. Atlantic seaboard	net ton	16.00	—	16.50
Fluorspar, gravel, f.o.b. mines	net ton	20.00	—	25.00
Manganese ore, 45% Mn and over	unit	.75	—	.85
Manganese ore, chemical (MnO_2)	gross ton	60.00	—	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO_3 and over per unit of WO_3	unit	9.00	—	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50	—	8.00
Uranium oxide, 96%	lb.	.....	—	.....
Vanadium pentoxide, 99%	lb.	6.00	—	.....
Pyrites, foreign, lump	unit	.17	—	.....
Pyrites, foreign, fine	unit	.17	—	.....
Pyrites, domestic, fine	unit	.14	—	.....
Ilmenite, 50% TiO_2	net ton	30.00	—	.....
Rutile, 95% TiO_2	net ton	200.00	—	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	3.00	—	3.25

Resales and overstocks make above prices approximate.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags	bbl.	$2.30
Lump lime, common, including container 300	bbl.	2.65
Common brick, at dock	M.	15.00
Hollow building tile, At factory, Perth Amboy, N. J. 8x12x12	M.	194.40
Hollow building tile, At factory, Perth Amboy, N. J. 12x12x12	M.	291.60
Yellow pine, 3x4 to 8x8, 20-24 ft. long	M.	40.00
Yellow pine, 3x4 to 8x8, 20-24 ft. long at Chicago	M.	39.50
Yellow pine, 3x4 to 8x8, 20-24 ft. long at St. Louis	M.	37.00
Roofings, tar felt (14 lb. per 100 sq.ft.)	ton	50.00
Roofings, tar pitch (in 400-lb. bbl.)	ton	19.00
Roofings, asphalt pitch	ton	30.00
Roofings, asphalt felt	ton	65.00
Roofings, slate-surfaced shingles, per roll of 108 sq.ft		2.10
Roofings, slate-finished shingles, 100 sq.ft		5.50
Linseed oil, raw in barrels	gal.	1.76
Linseed oil, 5 gal. cans	gal.	1.89
Red lead, dry, 100 lb. keg	lb.	.13
Red lead, in oil, 100 lb. keg	lb.	.14½
Red lead, dry, 5 lb. cans	lb.	.15
Red lead, in oil, 5 lb. cans	lb.	.16½
White lead, dry and in oil, 100 lb. keg	lb.	.13
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.13½
White lead, dry and in oil, 5 lb. cans	lb.	.15

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.66
Rivets, structural, ¾-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.35
Sheets, No. 10 blue annealed	100 lb.	3.55
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

CALVERT—The National Reduction Co. plans to build a rosin and turpentine plant. A. D. Little, Inc., 30 Charles River Rd., Cambridge, Mass., architect.

Arizona

HILLTOP—The Ajax Metal Mining Co. plans to build a 150-ton flotation mill. N. P. Wilson, manager.

HILLTOP—The Hilltop Mining & Smelting Co. plans to build a smelter. O. Fife, manager.

MESA—The City Council plans an election soon to vote on $60,000 bonds for extensions to the gas plant, etc.

California

AVALON—The city plans election soon to vote on $55,000 bonds for the construction of a gas plant on Catalina Island, here.

BENICIA — Kulman, Salz & Co., 603 Wells-Fargo Bldg., San Francisco, is having plans prepared by J. A. Wilcox, engineer, c/o owner, for the construction of a 3-story, 103 x 154-ft. tannery. Estimated cost, $60,000.

JULIAN—F. Tolbat Co., 2115 Logan Ave., San Diego, plans development at its mine here, to include the construction of a mill having a daily capacity of 20 tons. J. W. Lyons, supt.

Connecticut

EAST LYME—The White Beach Sanatorium, c/o Dr. S. J. Maher, 212 Orange St., New Haven, plans to build a sewage disposal plant at the sanatorium for tubercular children. Ford, Buck & Sheldon, Inc., 60 Prospect St., Hartford, engineers.

Florida

JACKSONVILLE — The Virginia-Carolina Chemical Co., 11 South 12th St., Richmond., Va., has awarded the contract for the construction of a 46 x 240-ft. factory on Mills St., here, to Huggers Bros., Bill Bldg., Montgomery, Ala. Estimated cost, $250,000. Noted April 1.

Georgia

ATLANTA — Adair & McCarty Bros., Walton Bldg., are having plans prepared by Lockwood, Greene & Co., engineers, Healy Bldg., for improvements to the fertilizer plant, including a new acidulating unit. Estimated cost, $25,000.

Illinois

VENICE—The Barber Asphalt Co. has awarded the contract for the construction of an oil refinery, to the Fruin-Colnon Construction Co., Merchants-Laclede Bldg., St. Louis, Mo. Estimated cost, $150,000.

WOOD RIVER—The White Star Refining Co., Avery and Grand Trunk Ry., has purchased a site and plans to build a petroleum refinery and pipe line from Wood River to the Mississippi River. Estimated cost, $300,000.

Iowa

FAIRPORT—The Commissioner of Fisheries, Department of Commerce, Washington, D. C., received bids for the construction of a laboratory building at the Biological Station here, from the Walsh Construction Co., 114½ West 3rd St., Davenport, $82,000; J. W. Hopp, 403 Granby Bldg., Cedar Rapids, $84,000; J. Solar, 5th and Cedar Sts., Davenport, $88,000. Noted May 15.

Kansas

ARKANSAS CITY—The city will soon award the contract for the construction of sanitary sewers and a disposal plant. C. E. McCrae, Republic Bldg., Kansas City, Mo., engineer.

Maryland

BALTIMORE—Johns Hopkins University, 321 Druid Hill Ave., has awarded the contract for the construction of a 1-story, 50 x 150-ft. addition to its chemical laboratory on Charles Street Ave., to Frainie Bros. & Haigley, 18 Clay St. Estimated cost, $55,000.

CURTIS BAY (Baltimore P. O.)—The Associated Chemical Co., Pennington Ave. and Cabin Branch, has awarded the contract for the construction of a 1-story, 96 x 100 x 155-ft. fertilizer factory, to W. G. Gischel & Co., South Baltimore. Estimated cost, $9600.

SALISBURY—The Farmers & Planters Co., c/o W. P. Ward, 406 Main St., plans to build a 1- and 2-story, 70 x 225-ft. fertilizer plant and warehouse; bone grinders and other fertilizer plant machinery will be installed in same. Estimated cost, $20,000.

SPARROWS POINT—The Bethlehem Steel Corp. plans to double the size of its tinplate plant here, increasing the number of sheet mills by twelve; also build an additional open-hearth furnace. Estimated cost, $25,000,000.

Michigan

SAGINAW—The McNally Vulcanizing Co., 408 Germania St., is having plans prepared by Cowles & Mutcheller, architects, Chase Block, for the construction of a 1-story, 25 x 60-ft. factory on North Park Ave. Plans include the installation of modern machinery for vulcanizing and tire repair work.

Minnesota

INTERNATIONAL FALLS—The city will soon receive bids for the construction of a hydrogen gas plant. Estimated cost, $75,000. W. Glenn, Minneapolis, engineer.

SHERBURN—E. E. Risley, village recorder, will receive bids until June 27 for the construction of a sewage disposal plant, etc. A. Fick, Boone, Ia., engineer.

ST. PAUL—The city will soon receive bids for a septic tank for the sewage disposal plant at Field and Sheridan Aves., 70 x 120-ft., 17 ft. below grade, walls 3 ft. 6 in. thick at bottom, 16 in. thick at grade. C. A. Hausler, City Hall, engineer.

WALNUT GROVE—D. A. Malloy, city clerk, will receive bids in July for the construction of a sewer and a disposal tank. Estimated cost, $50,000. Druar & Smith, 513 Globe Bldg., St. Paul, engineers.

Missouri

LOHMAN—The American Barytes Co., incorporated by W. C. Irwin, J. Hays and others of Jefferson City, plans to build a mill. Estimated cost, $10,000.

ST. LOUIS—The Scullin Steel Co., 6700 Manchester Ave., will build a steel rolling mill at 6700 Knox Ave., having a monthly capacity of 10,000 tons. Estimated cost, $2,000,000. Perin & Marshall, 2 Rector St., New York City, N. Y., engineers.

ST. LOUIS—The United Drug Co., 63 Leon St., Boston, Mass., plans to build an 8-story factory for the manufacture of rubber goods, drugs, etc., at San Francisco Ave. and Kings Highway. Estimated cost, $2,000,000. F. N. De Rosset, general manager.

Montana

CUT BANK—The City Council will soon award the contract for the construction of a sewerage system, to include two sewage disposal plants, septic tank, etc. Estimated cost, $48,000. H. P. Walter, Minot Bldg., Great Falls, engineer.

New Jersey

KEARNY (Arlington P. O.)—The White Tar Co. will soon receive bids for the construction of a 2-story, 100 x 200-ft. office building and factory. Estimated cost, $60,000. J. W. Cowper Co., Fidelity Bldg., Buffalo, N. Y., engineer.

LAMBERTVILLE—The Chemung Iron & Steel Co., 39 Cortlandt St., New York City, plans to build a 1-story, 100 x 380-ft. steel rolling mill here. Estimated cost, $100,000. E. F. Quirk, c/o owner, engineer.

NEWARK—The Patton Paint Co., Chester Ave., plans to build a 2-story, 61 x 121-ft. factory. Estimated cost, $65,000. J. H. & W. Ely, Fireman Bldg., architects and engineers.

New York

BROOKLYN—The Germania Importing Co., 41 Union Sq., New York City, will build a 2-story, 40 x 90-ft. chemical factory at 46th St. and 2nd Ave. Estimated cost, $20,000. O. Ullrich, 371 Fulton St., architect.

BROOKLYN—H. Kohnsten, 537 Columbia St., manufacturer of chemicals, has awarded the contract for the construction of a 1-story, 60 x 100-ft. factory on Columbia St., to Post & McCord, 101 Park Ave., New York City. Estimated cost, $30,000.

EASTWOOD—The Syracuse Rubber Co., Thompson Rd., Syracuse, recently incorporated with $3,000,000 capital, has awarded the contract for the construction of a 3-story, 60 x 200-ft. plant for the manufacture of cord tires for automobiles, to the Shane Steel Construction Co., 2109 Midland Ave., Syracuse.

JOHNSON CITY—Cook, Holland & Russell will soon award the contract for the construction of a factory on Grand Ave. for the manufacture of concrete building blocks. Complete equipment will be installed in same. Estimated cost, $40,000.

PHILADELPHIA—F. X. Baumert Co., Antwerp, is having plant prepared for the construction of a modern milk testing plant and cheese factory. Laboratory equipment will be installed in same. Estimated cost, $30,000.

North Carolina

NAVASSA—The Morris Fertilizer Co., Third National Bank Bldg., Atlanta, Ga., has awarded the contract for the construction of a fertilizer plant, mill building, niter house, etc., to the Elliott Building Co., Hickory. Estimated cost, $450,000.

STATESVILLE—The city plans to extend the water and sewer mains, to include the installation of additional filters, etc. Estimated cost, $150,000. L. B. Bristol, Mayor.

WILMINGTON—The Morris Fertilizer Co., Third National Bank Bldg., Atlanta, Ga., has awarded the contract for the construction of a fertilizer plant, having a capacity of 75,000 tons a year, to the Elliott Building Co., Hickory. Estimated cost, $125,000. Noted March 15.

Ohio

COLUMBUS—The board of trustees of the Ohio State University will soon award the contract for the construction of a 1-story, 140 x 205-ft. chemistry building on the campus. Estimated cost, $85,000. J. N. Bradford, c/o Ohio State University, architect.

COLUMBUS—The Columbus Tire & Rubber Co., Hayden Bldg., plans to build a 1-story, 100 x 340-ft. rubber factory on West Goodale St. Estimated cost, $92,000. Austin Construction Co., East 152nd St., Cleveland, architect.

COLUMBUS—The Henderson Tire & Rubber Co., Bucyrus, has awarded the contract for the construction of a 2-story, 100 x 300-ft. rubber factory on Goodale St., here, to Moor Bros., 1358 Franklin Ave. Estimated cost, $100,000.

ST. PARIS—The city will soon receive bids for the construction of a sewage disposal plant, to include a filter bed and septic tank. Estimated cost, $10,000. P. Lethig, Springfield, engineer.

Oklahoma

OKLAHOMA—The Hazelrigg Laboratories, recently incorporated with $50,000 capital, by J. E. Harbison, treasurer, 310 Mercantile Bldg., and others, plans to build a plant for the manufacture of chemicals.

TULSA—The Hofstra Manufacturing Co., manufacturer of insect powder, plans to install machinery in its plant. Estimated cost, $30,000. J. B. Gibbons, engineer.

TULSA—Dr. L. D. Latham, Bliss Bldg., plans to install a chemical laboratory in connection with the 3-story, 40 x 120-ft. hospital which he plans to build at 18th

and Quincy Sts. Total estimated cost, $100,000. Thompson & Fleming, 222½ Iowa Bldg., architects.

Oregon

CORVALLIS—J. Myers, secretary of the Board of Regents of the State Agricultural College, will soon award the contract for the construction of a 2-story, 56 x 220-ft. engineering laboratory on the college campus. Estimated cost, $130,000. J. V. Nennes, 1040 Chamber of Commerce Bldg., Portland, architect.

PORTLAND — The Portland Rubber Mills, Inc., 368 East 9th St., has awarded the contract for the construction of a 1-story, 75 x 200-ft. factory in South Portland, to T. Muir, Henry Bldg. Estimated cost, $20,000.

SALEM—The Oregon Pulp & Paper Co. will soon receive bids for the construction of a two-machine paper and sulphite pulp mill on the Willamette River. Estimated cost, $1,000,000. C. E. Eaton, Sherman Bldg., Watertown, N. Y., engineer.

Pennsylvania

DEAN—The Haws Refractories Co., Johnstown, plans to build a large firebrick plant here, having a capacity of 100,000 bricks per day. H. L. Tredennick, Johnstown, president.

PHILADELPHIA — The Hess-Bright Manufacturing Co., Front and Erie Sts., plans to build a 2-story, 42 x 105-ft. laboratory. F. R. Watson, 1211 Walnut St., architect.

WISSINOMING—The Quaker City Rubber Co., 629 Market St., has awarded the contract for the construction of a 2-story, 140 x 160-ft. factory, to J. S. Rogers, Drexel Bldg., Philadelphia.

Texas

DALLAS—The State Refining Association, 1403 American Exchange National Bank Bldg., plans to build a skimming plant having a capacity of 500 barrels. S. Bonner, treasurer.

NORTH FORT WORTH—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a helium production plant, to the Central Contracting Co., 520 Beatty Bldg., Houston. Estimated cost, $448,000.

WICHITA FALLS—The committee on Northwest Texas Insane Asylum will soon award the contract for the construction of four buildings for the asylum here, including disposal plant, etc. Estimated cost, $350,000. C. H. Page & Bros., Austin National Bank Bldg., Austin, architect.

Washington

HOQUIAM—The Western Rolling Mills Corp. will soon award the contract for the construction of the first unit of its steel rolling plant to be 70 x 300 ft. J. Johnson, manager.

West Virginia

CAMP HUMPHRIES — The United States War Department, Washington, D. C., will soon receive bids for the construction of an artificial gas plant and distribution system to serve 10,000 people. Lieutenant G. A. Caine, Camp Humphries, engineer.

FAIRMONT—The West Virginia Metal Products Corp., incorporated with $2,500,000 capital stock, plans to build a large brass rolling mill. J. E. Watson, president.

Wisconsin

SHEBOYGAN—The North Star Rubber Co., c/o L. Hoffmeister, 176 16th St., Milwaukee, plans to build a 2-story, 60 x 95-ft. rubber plant on Michigan Ave., here. Estimated cost, $45,000.

Alberta

CALGARY—The City Council has appropriated $350,000 for the construction of a sewage disposal plant.

Ontario

BANCROFT—The Canada Marble Co. plans to build a plant. Estimated cost, $500,000. Architect not selected.

DUNDAS—A. W. Draeseke, chairman of the sewer committee, will receive bids until June 23 for the construction of sewage disposal works, sewage pumping station and force main, out fall sewer, sewage pumping machinery, sprinkler equipment, etc. J. S. Fry, town, clerk. Noted May 1.

HAMILTON—The National Paper Goods Co., Ltd., plans to build a 56 x 100-ft. factory. Estimated cost, $80,000.

KITCHENER—The Imperial Oil Co., Ltd., 181 Brock St., Sarnia, has awarded the contract for the construction of an addition to its oil plant, here, to Shulte Bros. & Co., 35 Albion St., Brantford. Estimated cost, $20,000.

PORT COLBORNE—The Canada Cement Co., 273 Craig St., W., Montreal, Que., plans to build a potash recovering plant. Estimated cost, $150,000.

WELLAND—The Imperial Oil Co., 56 Church St., Toronto, has awarded the contract for the construction of an oil plant, to Schutz Bros., 35 Albion St., Brantford. Estimated cost, $40,000. Noted June 1.

WESTON—The K. & S. Canadian Tire & Rubber Co. is having plans prepared by Hynes, Feldman & Watson, architects, McKennon Bldg., Toronto, for the construction of a 1-story factory. Estimated cost, $80,000.

Coming Meetings and Events

THE AMERICAN CHEMICAL SOCIETY will hold its Fall meeting in Philadelphia, Pa., Sept. 2-6 inclusive.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its Fall meeting in Chicago, Sept. 23-25 inclusive.

THE AMERICAN ELECTRO-PLATERS' SOCIETY will hold its 1919 convention in Philadelphia, Pa., July 1-3.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will hold its 1919 convention in Philadelphia, Sept. 29 to Oct. 4.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its Summer meeting at Boston, Mass., June 18-21. A symposium is planned on electric furnaces.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its Fall meeting in Chicago, Ill., Sept. 22-27.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its 22nd annual meeting at Atlantic City, N. J., June 24-27. The headquarters will be at the Hotel Traymore.

THE AMERICAN STEEL TREATERS' SOCIETY will hold its first annual convention in Chicago, Ill., Sept. 22-27.

THE FIFTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in Chicago, Ill., Sept. 22-27 inclusive.

THE INSTITUTE OF METALS DIVISION of the A. I. M. E. will hold its next meeting in Philadelphia, Pa., Sept. 29 to Oct. 4.

THE INSTITUTE OF METALS will hold its Autumn meeting in Sheffield, England, Sept. 24-25.

THE INTERALLIED CHEMICAL CONFEDERATION will hold its next meeting in London, July 15-18, 1919.

THE NATIONAL FERTILIZER ASSOCIATION will hold its 26th annual convention the week of June 23 at the Hotel Griswold, Eastern Point, New London, Conn.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its 27th annual meeting at Johns Hopkins University, Baltimore, Md., June 25-28.

Industrial Notes

THE CHICAGO PNEUMATIC TOOL CO. has moved its Milwaukee office from Room 1305, Majestic Bldg., to Room 1418 in the same building, where more convenient quarters have been obtained.

THE PRATT ENGINEERING & MACHINE CO., Atlanta, Ga., has been awarded a contract for the erection of a complete fertilizer plant for the Southern Fertilizer & Chemical Co. at Savannah, to cost approximately $500,000. This new plant is to take the place of one recently destroyed by fire and will be ready for operation in September, 1919.

THE BLAW-KNOX CO., Pittsburgh, Pa., manufacturers of steel products, announces the appointment of Mr. J. E. Mason as manager of field sales. For the past four years Mr. Mason has been connected with the McGraw-Hill Co., having been in charge of the Chicago office of *Engineering News-Record* since July, 1917.

THE ANNISTON STEEL CO., Anniston, Ala., announces the appointment of W. W. Tarleton as director of the salvage division, sales department. Mr. Tarleton will be in charge of the sale of iron and woodworking machinery, engines and boilers and miscellaneous equipment recently acquired from the Illinois Car & Equipment Co.

THE BOOTH-HALL CO., designer and builder of electric furnaces, announces removal of the executive and sales office to Rooms 1007-1008 Hearst Bldg., 326 W. Madison St., Chicago, Ill.

THE ELECTROLABS CO., New York, announces that the Paschall Oxygen Co., Philadelphia, will increase the capacity of its plant 25 per cent, making a total of 1,000 Levin cells in operation.

THE AMERICAN STEAM CONVEYOR CORP., Chicago, Ill., announces the appointment of Mr. Charles H. Florandin, formerly of the National Electric and Welding Co., New York, as general manager of its Eastern territory, with headquarters at 110 W. 40th St., New York.

THE MARLAND REFINING CO., Ponca City, Okla., has recently advised its employees that it has determined on a plan for paying labor dividends based upon amount of salary or wages received. The management regards the labor of its employees as an investment by them in the business and will pay them a dividend of its earnings made by capital and their labor. This is said to be the first time that a plan of labor dividends has been tried in the oil business.

SCHAAR & CO., Chicago, Ill., announces the removal to larger quarters at 556-560 W. Jackson Blvd., where the manufacturing, selling and executive departments will be under one roof.

THE UNITED FILTERS CORP., New York, announces the appointment of Mr. C. B. Oliver as manager of the Chicago office with headquarters in the Peoples' Gas Building.

MR. JAMES INGLIS, president of the American Blower Co., sailed from New York on May 15 as a member of a commission appointed to confer with European cotton interests on post-war conditions in the cotton industry throughout the world and with special reference to the proposed world cotton conference to be held in New Orleans next October.

THE COMMITTEE OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, of which Dr. R. F. Bacon, director of the Mellon Institute, is chairman, is assisting the Government in disposing of chemical plants and surplus stocks of chemicals and apparatus. Much of this material is difficult to store and must be sold at once.

MR. M. H. JONES, who has been connected with the Westinghouse Electric & Manufacturing Co. for the past fifteen years as assistant to the manager of the Philadelphia district, has resigned his position to become sales manager of the Standard Electric & Elevator Co. of Baltimore.

THE ALLIED MACHINERY CO. OF AMERICA has increased its capital stock to $5,000,000, the step being necessitated by the decision of the American International Corp. to group all of its machinery export selling subsidiaries under one head. The Allied Construction Machinery Corp. will be absorbed by the American Machinery Co. of America. The Allied Machinery Co. de France and the Allied Machinery Co. d' Italia will retain their corporate entities, but their parent corporation will be the Allied Machinery Co. of America rather than the American International Corporation as before. This is also true of the Horne Co., Ltd., of Japan, which was purchased early in the year by the American International Corporation. Mr. J. W. Hook will continue as president of the Allied Machinery Co. of America, in general charge of the business. Messrs. F. A. Monroe, S. T. Henry and T. G. Nee have been elected vice-presidents. Mr. Monroe is in charge of the administrative affairs of the company. Mr. Henry is in charge of sales and advertising and Mr. Nee is at present in Japan, devoting his attention to the affairs of the Horne Co., Ltd. Mr. R. P. Redier is general sales manager of the company, with headquarters at Paris.

HAMILTON & HANSELL, INC., New York City, announces the selling of the following electric furnaces: One 1000-lb. Rennerfelt furnace, 400 k.v.a., to the Steel Alloys Co. of America, to be erected at its plant in Bayway, Elizabeth, for the reduction of tungstic acid to metallic tungsten. One 1000-lb. Rennerfelt furnace, 200 k.v.a., to the British American Nickel Co., Ottawa, Canada, to be erected at its Deschene plant in Quebec, for melting nickel. One 150-k.v.a. single-phase pot furnace with its complete

equipment, sold to the Government of the Netherlands, Colonial Department, to be erected at the experimental station in Batavia, Java, Dutch East Indies.

LEEDS & NORTHRUP CO., Philadelphia, Pa., has opened a pyrometer sales and service department at 1304 Monadnock Block, Chicago. A complete standardization equipment will be maintained and certification of thermocouples and of pyrometer equipments will be furnished in terms of standards certified by the United States Bureau of Standards. Particular attention will be given to maintaining equipment after installation. The office will be in charge of Mr. Henry Brewer.

MARDEN, ORTH & HASTINGS, INC., of New York City, moved its dyestuff and intermediate department to Bound Brook, N. J. An office at 136 Liberty Street, New York City, will be maintained for the metropolitan salesmen of the dyestuffs and intermediates department, and also considerable stocks will be carried in New York for the quick deliveries to trade in that vicinity.

THE STANDARD ELECTRIC & ELEVATOR CO., INC., Baltimore, Md., has opened a New York office at 280 Broadway, in charge of C. A. Harrington, formerly sales manager of the company.

Directors of the E. I. du Pont Powder Co. have elected the following new vice-presidents: Charles A. Meade, W. S. Carpenter, Jr., J. B. D. Edge, A. Felix du Pont, William C. Spruance and Charles A. Patterson. These are the recently appointed members of the new executive committee, and their election as vice-presidents follows the custom of the company, which gives the title of vice-president to the active heads of departments.

THE BLAW-KNOX CO., Pittsburgh, Pa., has taken over the manufacture and field operation of the Uni-Form System of reinforced concrete floor and roof construction, which is now incorporated in the steel forms department of the Blaw-Knox Co. and will be known as "Blawforms."

THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO., East Pittsburgh, Pa., announces the appointment of Mr. H. L. Garbutt as manager of the supply division of the San Francisco office of the company.

THE CARBON STEEL CO., Pittsburgh, Pa., announces the return from the aviation service in Italy of Mr. Harry S. Finkenstaedt as Western sales agent.

THE ALKALI EXPORT ASSOCIATION, INC., New York, is composed of five companies: The Pennsylvania Salt Mfg. Co., Philadelphia; The Solvay Process Co., Syracuse, N. Y.; The Michigan Alkali Co., New York; Columbia Chemical Co., Cincinnati; The Hooker Electrochemical Co., Niagara Falls, N. Y.

THE BUFFALO FORGE CO. announces that Mr. C. C. Cheyney has returned to take charge of its Chicago office and store. Lieut. Cheyney was commissioned in the Navy and had charge of the mechanical repair shops at the Naval Aviation Station, Pensacola, Fla. Capt. H. H. Downes, 12th U. S. Engineers (Railway) has returned from France, and expects that after receiving his discharge he will take charge of the Buffalo Forge Co.'s interests in the St. Louis territory.

THE WHEELER CONDENSER & ENGINEERING CO., Carteret, N. J., manufactured and shipped during the month of April 879,900 lb. of seamless drawn brass, copper and tungsten tubes.

THE INTERNATIONAL OXYGEN CO., Newark, N. J., announces the appointment of Mr. Preston Belvin as district sales engineer, in charge of the Pittsburgh district sales work, with headquarters at 1310 National Bank Bldg. The Chicago office of this company has been moved from 223 Railway Exchange Bldg. to 817-820 Chicago Stock Exchange Bldg., with Mr. Philip G. Wesley in charge.

THE SCIENTIFIC UTILITIES CO., INC., New York, manufacturer of laboratory glassware and metal apparatus, with offices at 84 East 10th St., has raised its capital to $30,000.

THE BETSON PLASTIC FIRE BRICK CO., Rome, N. Y., elected Mr. Frank J. Jewell as president and secretary and Mr. Nelson Adams, vice-president and treasurer. The company's products are plastic firebrick for boiler furnace linings and baffle walls and Hi-heat cement for use in the boiler room.

THE CELITE PRODUCTS CO., New York City, announces the appointment of Mr. Edward F. Davis as sales engineer in Northern New Jersey on the application of Sil-O-Cel insulation and Filter-Cel for filtration.

Manufacturers' Catalogs

THE KINITE CO., Milwaukee, has issued a 4-page folder entitled "Kinite, A Patented Alloy Steel."

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis., calls attention to a six-page folder on melting metal with electrically heated pots.

THE GRISCOLM-RUSSELL CO., New York: Bull. No. 230 illustrates and describes the Reilly water heater.

THE DENVER FIRE CLAY CO., Denver, Colo., calls attention to two new bulletins. Bull. No. 125 on firebrick, metallurgical tile, fire clay, etc., illustrates and describes these products. Bull. No. 100 treats metallurgical clay goods, muffles, crucibles and scorifiers.

THE BUCKEYE DRYER CO., INC., Columbus, Ohio: Cat. No. 3 is a new 44-page booklet which deals with Buckeye dryers for organic and inorganic materials. Many illustrations are given together with descriptive matter.

THE MERRILL CO., San Francisco, Cal., has issued a booklet which gives the comments of the technical press on the Crowe vacuum precipitation process, which is a new method of precipitating cyanide solutions in conjunction with either the Merrill precipitation process or with zinc boxes.

THE AMERICAN LAVA CO., Chattanooga, Tenn., announces a new publication entitled "Lava for Mechanical and Electrical Purposes." This 16-page booklet illustrates and describes nature and physical properties, mechanical properties, electrical properties, uses and cost and composition lava.

THE CHAS. A. SCHIEREN CO., New York City has just received from the press Cat. No. 10, issued April, 1919, on Schieren leather beltings. It is an attractive 40-page booklet dealing with tanning methods, the different qualities of belting, general price list on Duxbak leather belting, leather link belting with price list, round leather belting, wire-screwed solid round belting, cut lacing, hydraulic leather, belt cement wafers, waterproof cement and flyfoot belt dressing. Many illustrations are given in color to illustrate these products. Schieren Engineering Service is a section which give a definite plan for making belting cost less and go further.

New Publications

STANDARD SPECIFICATIONS FOR PURITY OF RAW LINSEED OIL FROM NORTH AMERICAN SEED. Industrial Standards No. 57, published by the Bureau of Foreign and Domestic Commerce.

NEW BUREAU OF STANDARDS PUBLICATIONS: Tech. Paper No. 126. A study of the Goutal method for determining carbon monoxide and carbon dioxide in steels. By J. R. Cain and Earl Pettijohn; No. 76. Aluminium and Its Light Alloys.

NEW UNITED STATES GEOLOGICAL SURVEY PUBLICATIONS: 1:1 Cadmium in 1918. By C. E. Siebenthal (Mineral Resources, 1918, Part 1), published May 8, 1919; 1:21. Gold and Silver in 1917. General Report. By H. D. McCaskey and J. P. Dunlop (Mineral Resources, 1917, Part 1), published May 9, 1919; 1:22. Antimony in 1917. By Edson S. Bastin (Mineral Resources, 1917, Part 1), published May 13, 1919; 11:28. Clay-Working Industries and Building Operations in the Larger Cities in 1917. By Jefferson Middleton. (Mineral Resources, 1917, Part 11), published May 12, 1919; 11:29. Lime in 1917. By G. F. Laughlin, (Mineral Resources, 1917, Part 11), published May 13, 1919.

U. S. DEPT. OF LABOR PUBLICATION on Treatment of Industrial Problems by Constructive Methods. A pamphlet and chart on methods of redesigning labor turnover and improving morale in plant organization.

SUGGESTIONS FOR IMPROVING PLANT ORGANIZATIONS. A report of a survey of 200 plants and works with suggestions for their improvement.

THE CALIFORNIA STATE MINING BUREAU, San Francisco, has issued Bull. 84, which is the third annual report of the State Oil and Gas Supervisor of California for the fiscal year 1917-18.

THE UNITED STATES NATIONAL MUSEUM, Bull. 102, Vol. 1. The Mineral Industries of the United States: The Energy Resources of the United States: A Field for Reconstruction. A survey of the situation in domestic fuels, petroleum and power, made in anticipation of the time when the United States must more systematically employ its energy resources.

Technology, The Journal of the Manchester Municipal College of Technology, Manchester, England. A record of investigations undertaken by members of the college.

NEW BUREAU OF MINES PUBLICATIONS: Bull. 144. Report of a Joint Committee Appointed from the Bureau of Mines and the United States Geological Survey by the Secretary of the Interior to Study the Gold Situation; Tech. Paper 214. Motor Gasoline Properties, Laboratory Methods of Testing, and Practical Specifications. By E. W. Dean; War Minerals Investigations Series No. 12, The Jones Process for Concentrating Manganese Ores, Results of Laboratory Investigations. By Peter Christianson and W. H. Hunter; Minerals Investigations Series No. 13. Cost of Producing Ferro-Grade Manganese Ores. By C. M. Weld and W. R. Crane.

Stocks and Bonds

Closing Bid and Asked Quotations June 11, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am.Ag.Ch.	108½	108¾	Mat.Al.Wk.	35	40
do.pf	99½	100½	Ten. C. & C.	13½	14
Barrett Co.	136½	137½	Un. Dyewood.	62	63
do.pf	118	119	do. pf.	97	97½
Gen.Chem.	180	195	Va.-Car. Ch.	75½	76
do.pf	103	107½	do. pf.	113½	114
Int.Ag.Ch.	44½	45			
do. pf.	84½	85½			

Bonds

	Bid	Ask
Am. Ag. Ch., 1st cv. 5s, '28	98½	99
Am. Ag. Ch., cv. db. 5s, '24	106½	109
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32	82½	83
Va.-Car. Ch., 1 mtg. 5s, '23	97	97½
Va.-Car. Ch., cv. db. 6s, '24	101½	102½

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co.	90½	92	P-A Pet & Tr.	98	98½
Cal. Pet.	37½	38	do. pf.	167	174
do. pf.	83	83½	Pierce Oil	24½	25
Col. G. & E.	55½	55½	Royal Dutch	116½	116½
Mex. Pet.	185½	186	Sinclair O & R	63½	64
do. pf.	106½	110	Texas Co.	273	274
Ohio Cit. Gas.	56½	56½	Tex. Pac. Ld. Tr.	425	500
do. pf.	....	....	Tidewater Oil.	242	248
Ohio Fuel S.	51½	52			
Okla. P. & R.	10½	10½			

Bonds

	Bid	Ask
Columbia Gas & Electric, 1 5s, '27	88½	89
Col. G. & El., std. 1 5s, '27	88½	....
Pan-Am. Pet. & Tr. 1 6s, '19-'27	140	165
Pierce Oil, cv. db. 6s, '24	105	106½
Pierce Oil, cv. 5% Notes, '20	117½	128
Sin. O. & R. 1 In.7s, '20, with stk. war.	140	150
Sin. O. & R. 1 In. 7s, '20 without stk. war.	99½	100
Texas Co., db. 6s, '31	102	102½
Union Oil of Cal. 1 5s, '31	93½	94½
United Fuel Gas 1 mtg. 6s, ser.A, '36	94½	97

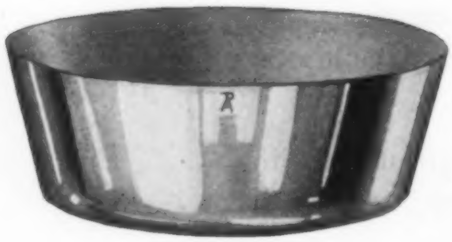
IRON AND STEEL SECURITIES

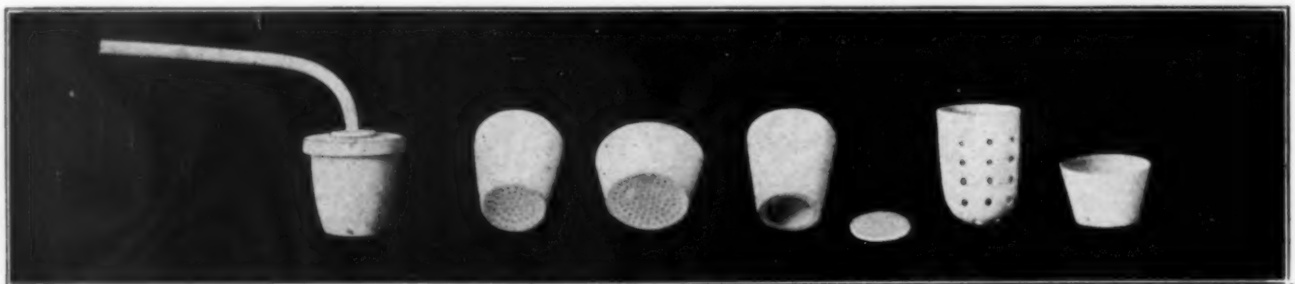
	Bid	Ask		Bid	Ask
Am. St. F.	97½	97½	Pitts. Ste. pf.	96	99
Beth. Steel	88	88½	Rep. Iron & Steel	89	90
do. class B.	90½	90½	do. pf.	104½	105
do. pf., 8%	114½	114½	Sloss Sheff. I. & S.	65	66
do. pf., 7%	102	110	do. pf.	90	94
Central Fdry.	21½	22	Superior Steel.	49	50
do. pf.	46	48	do. 1 pf.	102	105
Col. F. & I.	49	49½	Trans. & W. Steel	56	57
do. pf.	103	125	Un. Alloy St.	52	52½
Cruc. Steel	92½	92½	U.S.C.I.P.&F.	33½	33½
do. pf.	100½	103	do. pf.	64	65
Great No. Ore	47½	47½	U. S. Steel	108½	108½
Gulf Sta. Steel	66½	68	do. pf.	116½	116½
do. 1 pf.	94	98	Va. Coal,I&C.	69	71
Lack. Steel	85	86			
Mid.St.& Ord.	51½	51½			
Nova Scotia Steel	87½	88			

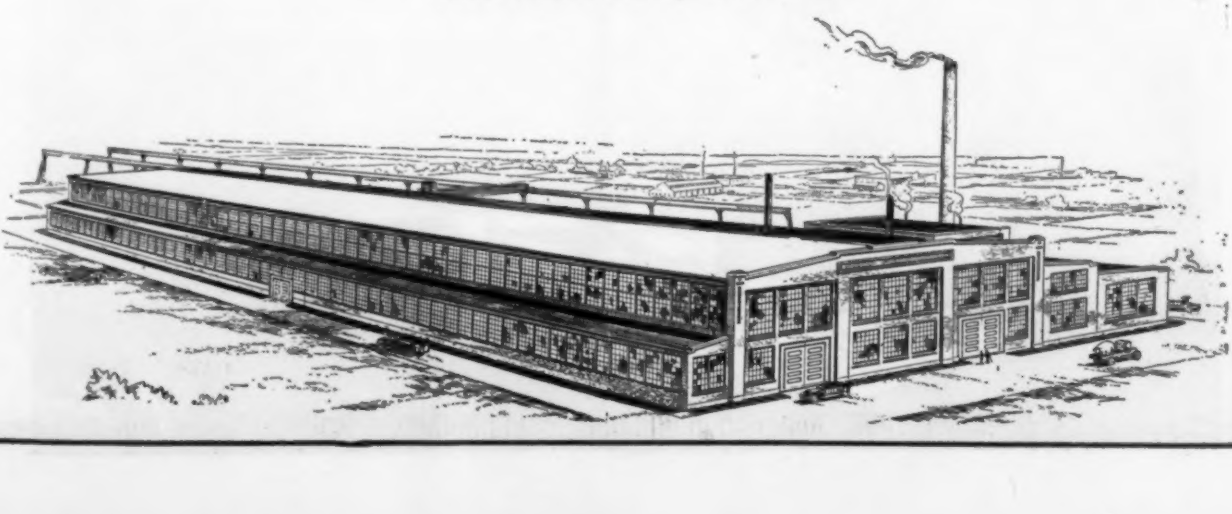
Bonds

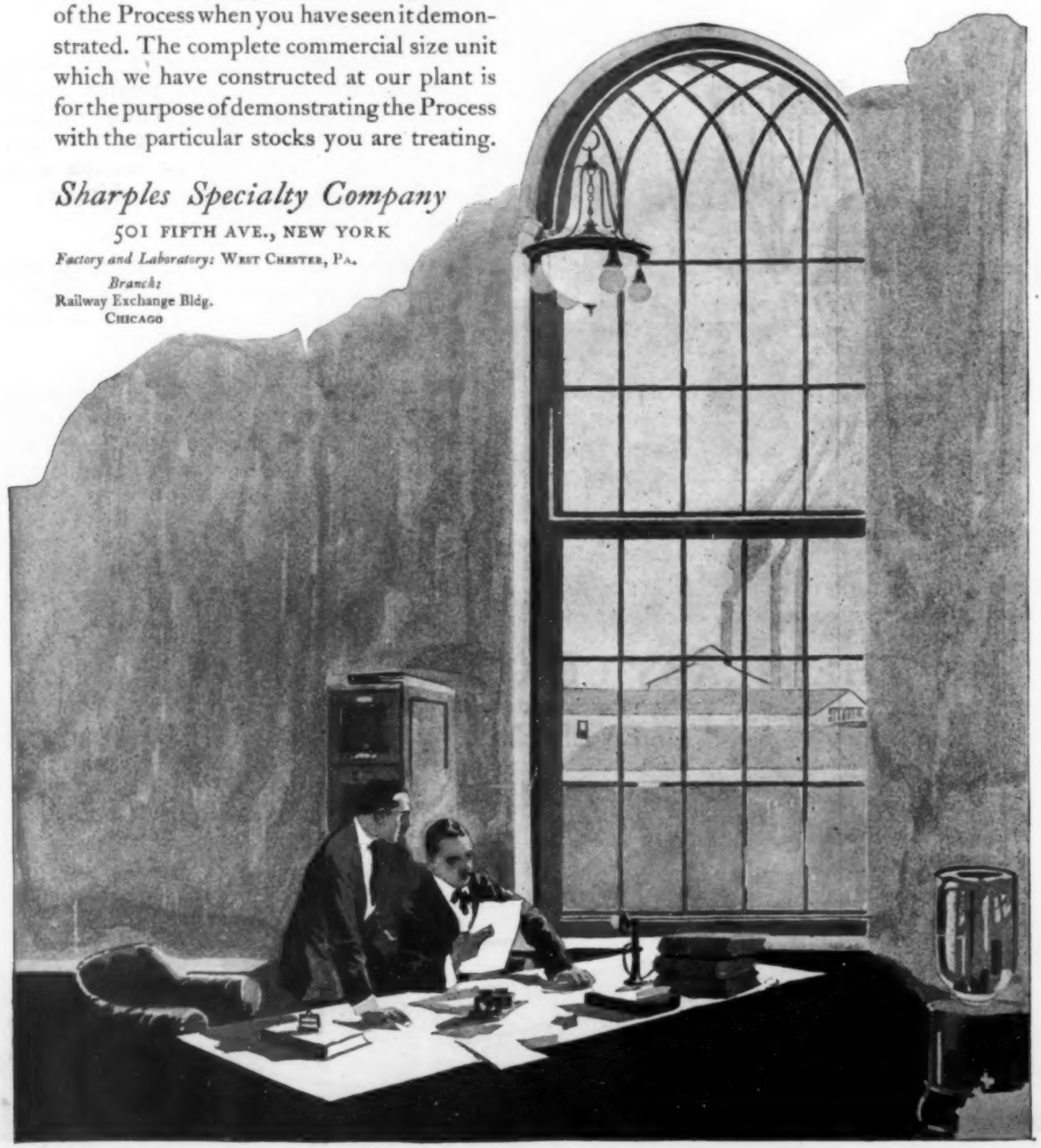
	Bid	Ask
Beth. Steel, 1 ext. gtd. S.F. 5s, '26	96½	96½
Beth. Steel, 1 In. ref. 5s, Ser. A, '42	90½	..
Beth. Steel, P. M. & I. S. F. 5s, '36	89	89½
Buff. & Susq. Iron, 1 S. F. 5s, '32	91	96
Cent. Found. 1 mtg. S. F. 6s, '21	80½	82
Col. F. & I., gn. S. F. 5s, '43	91	93½
Ill. Steel, db. 4½s, '40	84½	86
Ind. Steel, 1 mtg. gtd. 5s, '52	97	97½
Lack. Steel, 1 5s, '23	97	97½
Lack. Ste., 1 con. mtg. cv. 5s, Ser. A, '50	93	95½
Mid. St. & Ord., clt. cv. S. F. 5s, '36	89½	90½
Nat. Tube, 1 mtg. gtd. 5s, '52	98½	99
Rep. I. & S., S. F. mtg. 5s, '40	95	97½
Tenn. C. & I. R.R., gn. 5s, '51	93	94
U. S. Steel, S. F. 5s, '63	100	104
Va. C., I. & C., 1 5s, '49	85½	88½

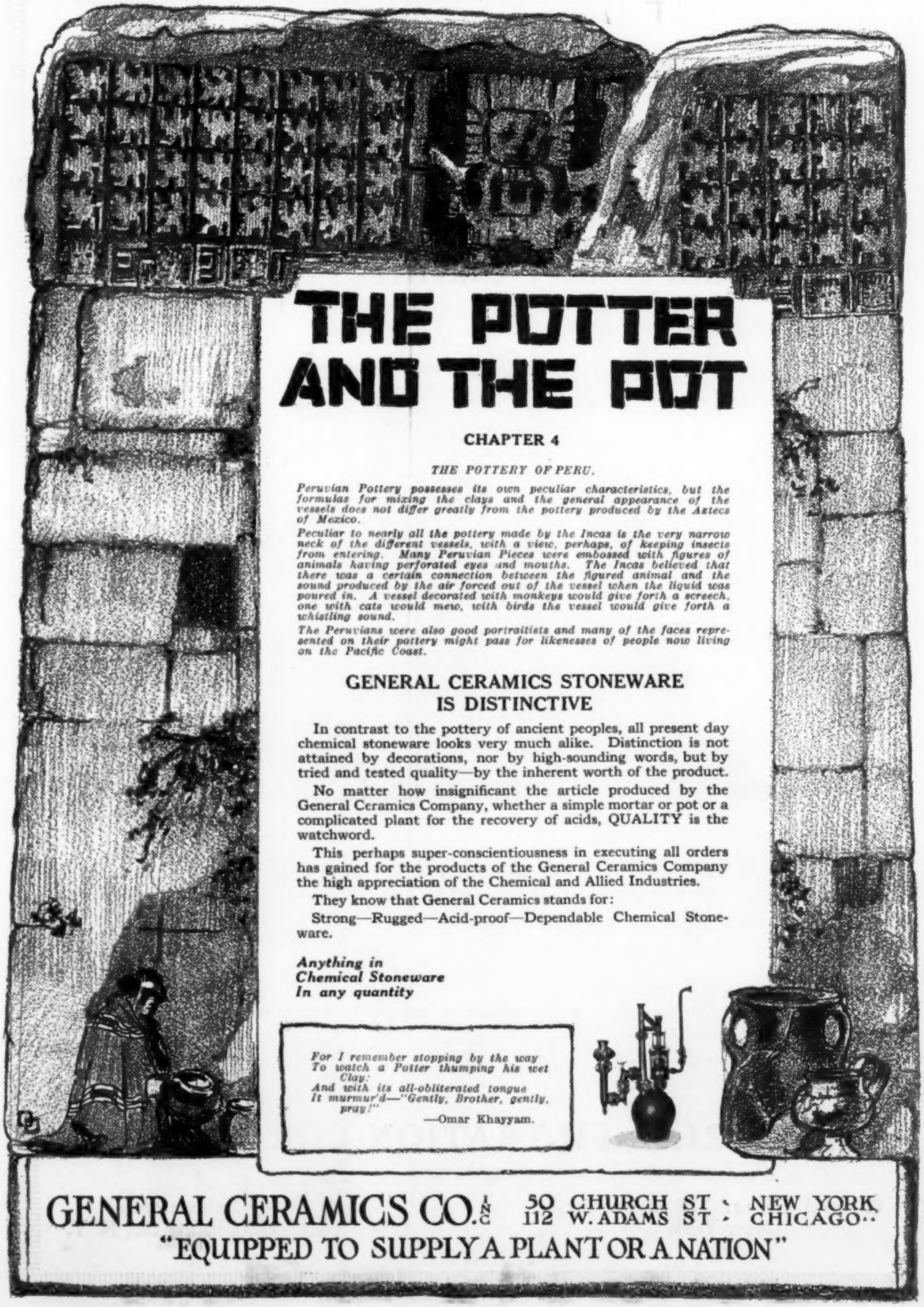

IF YE BREAK FAITH WITH THEM WHO DIE
THEY WILL NOT SLEEP,
THO POPPIES GROW IN FLANDERS FIELDS










THE POTTER AND THE POT
CHAPTER 4
THE POTTERY OF PERU.
Peruvian Pottery possesses its own peculiar characteristics, but the formulas for mixing the clays and the general appearance of the vessels does not differ greatly from the pottery produced by the Aztecs of Mexico.
Peculiar to nearly all the pottery made by the Incas is the very narrow neck of the different vessels, with a view, perhaps, of keeping insects from entering. Many Peruvian Pieces were embossed with figures of animals having perforated eyes and mouths. The Incas believed that there was a certain connection between the figured animal and the sound produced by the air forced out of the vessel when the liquid was poured in. A vessel decorated with monkeys would give forth a screech, one with cats would mew, with birds the vessel would give forth a whistling sound.
The Peruvians were also good portraitists and many of the faces represented on their pottery might pass for likenesses of people now living on the Pacific Coast.
GENERAL CERAMICS STONEWARE IS DISTINCTIVE
In contrast to the pottery of ancient peoples, all present day chemical stoneware looks very much alike. Distinction is not attained by decorations, nor by high-sounding words, but by tried and tested quality—by the inherent worth of the product.
No matter how insignificant the article produced by the General Ceramics Company, whether a simple mortar or pot or a complicated plant for the recovery of acids, QUALITY is the watchword.
This perhaps super-conscientiousness in executing all orders has gained for the products of the General Ceramics Company the high appreciation of the Chemical and Allied Industries.
They know that General Ceramics stands for:
Strong—Rugged—Acid-proof—Dependable Chemical Stoneware.
Anything in Chemical Stoneware In any quantity
For I remember stopping by the way
To watch a Potter thumping his wet Clay:
And with its all-obliterated tongue
It murmur'd—"Gently, Brother, gently, pray!"
—Omar Khayyam.
GENERAL CERAMICS CO. INC
50 CHURCH ST · NEW YORK
112 W. ADAMS ST · CHICAGO
"EQUIPPED TO SUPPLY A PLANT OR A NATION"

Continuous Leaching and Washing

of

Cinder, Crystals and other Granular Products

The Dorr Multi-Deck Washing Classifier
(Patented)

This machine is used for leaching and washing granular materials such as cinder from calcining operations, various crystals and sandy products. Machines are built with from 2 to 6 decks. The leaching is done in the first two or three decks depending upon the time of contact required and in the following decks the solids are washed free from the liquor produced. Wash water or liquor introduced in the last deck flows from deck to deck thru outside launders or pipes counter current to the solids. A high washing efficiency is obtained with a comparatively small amount of wash water. The power required is exceedingly low and only part of one man's time is required for attention.

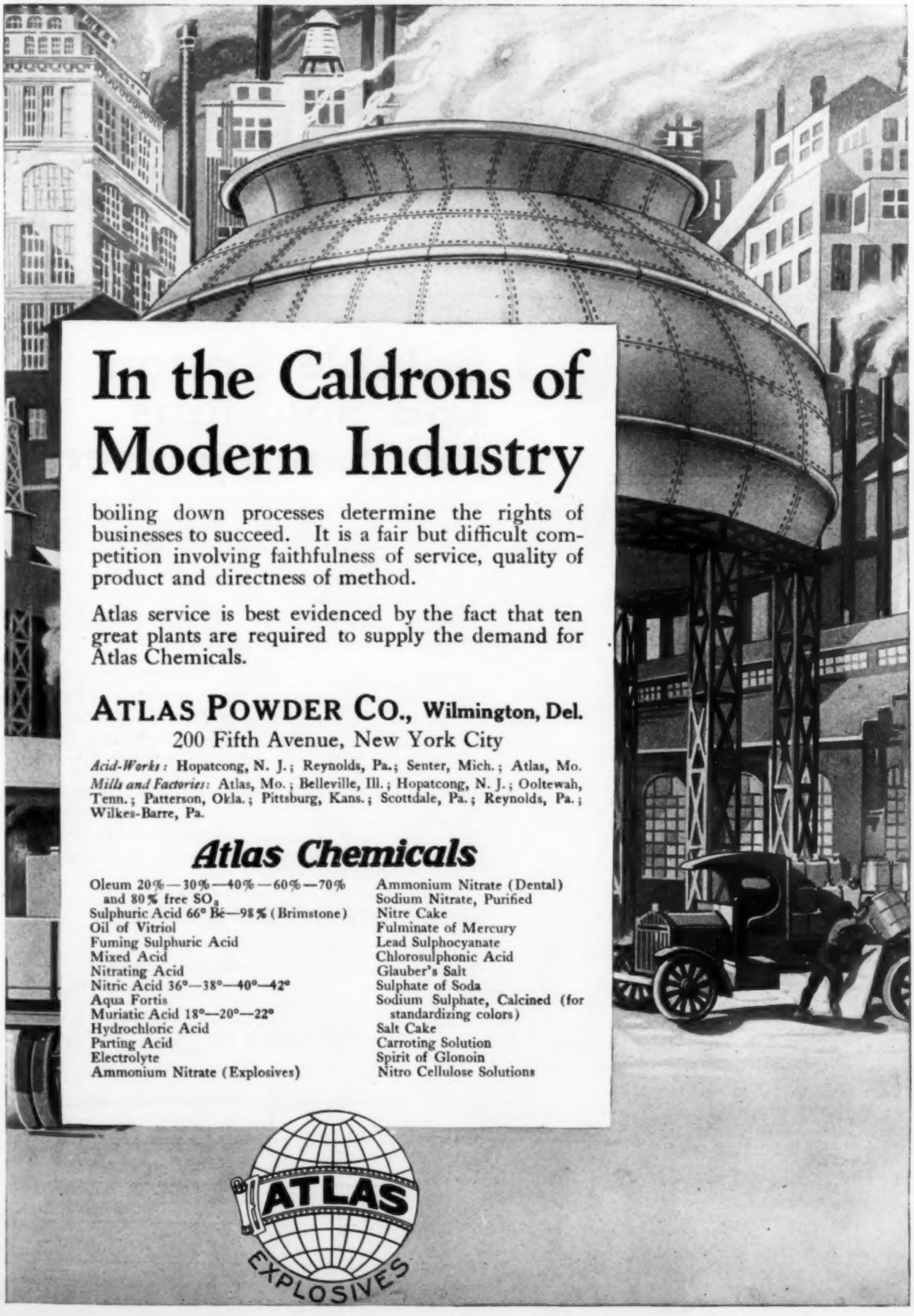
One plant using a 3 deck Classifier for leaching cinders is obtaining a 98% recovery of the soluble constituents, making a 30 deg. Be liquor. The leached and washed cinder is discharged with a low moisture content in good condition to be carried on a belt conveyor.

Machines are built with capacities from a few tons to several hundred tons per 24 hours, both for acid and alkaline liquors.

THE DORR COMPANY

Engineers

New York, 101 Park Avenue Denver, 1009 17th Street London, 16 South Street



In the Caldrons of Modern Industry

boiling down processes determine the rights of businesses to succeed. It is a fair but difficult competition involving faithfulness of service, quality of product and directness of method.

Atlas service is best evidenced by the fact that ten great plants are required to supply the demand for Atlas Chemicals.

ATLAS POWDER CO., Wilmington, Del.
200 Fifth Avenue, New York City

Acid-Works: Hopatcong, N. J.; Reynolds, Pa.; Senter, Mich.; Atlas, Mo.
Mills and Factories: Atlas, Mo.; Belleville, Ill.; Hopatcong, N. J.; Ooltewah, Tenn.; Patterson, Okla.; Pittsburg, Kans.; Scottdale, Pa.; Reynolds, Pa.; Wilkes-Barre, Pa.

Atlas Chemicals

Oleum 20%—30%—40%—60%—70% and 80% free SO_3
Sulphuric Acid 66° Bé—98% (Brimstone)
Oil of Vitriol
Fuming Sulphuric Acid
Mixed Acid
Nitrating Acid
Nitric Acid 36°—38°—40°—42°
Aqua Fortis
Muriatic Acid 18°—20°—22°
Hydrochloric Acid
Parting Acid
Electrolyte
Ammonium Nitrate (Explosives)
Ammonium Nitrate (Dental)
Sodium Nitrate, Purified
Nitre Cake
Fulminate of Mercury
Lead Sulphocyanate
Chlorosulphonic Acid
Glauber's Salt
Sulphate of Soda
Sodium Sulphate, Calcined (for standardizing colors)
Salt Cake
Carroting Solution
Spirit of Glonoin
Nitro Cellulose Solutions

SYMBOLS OF SULPHUR

Texas
Gulf Sulphur

99½ PER CENT. PURE

Ancient

The peculiar cryptogram on the left was symbolic of sulphur to the ancients. Its origin is hard to trace.

The Babylonian astrologers engaged in magic arts and associated the heavenly bodies with minerals. The Egyptians engaged in chemistry in a disjointed way, and when the Arabs overran Egypt and parts of Europe, they appear to have made a good beginning in the study of science. Mediæval and Renaissance manuscripts abound in alchemistic symbols although many of them that have been handed down, belong to far more ancient days.

This particular mark presumably indicated Sulphur in exactly the same sense that our WORD Sulphur indicates it, signifying no particular grade of purity.

Modern

The mark on the right is symbolic of sulphur 99½ per cent. pure. Texas Gulf Sulphur coming from the Gulf Coast Section is constantly subjected to chemical analyses which have proven its exceptional quality.

The chemist of today need not work in the dark. He may have knowledge of the purity of the sulphur (brimstone) he uses as well as the symbol by which it is marked.

There is an ample supply of Texas Gulf Sulphur to meet your requirements for many years and splendid transportation facilities are available to deliver Texas Gulf Sulphur to you when needed.

If you are interested in Sulphur, communicate with our Sales Department.

TEXAS GULF SULPHUR CO.

WALTER H. ALDRIDGE
PRESIDENT

50 E. 42ND ST., NEW YORK

A. H. PECK
SALES MANAGER

H. J. BAKER & BRO., 81 FULTON ST., NEW YORK, N. Y.
Agents for New York and Southeastern District

CHARLES COOPER & CO., 194 Worth Street, New York
Established 1857
MANUFACTURING CHEMISTS

Specialties:
Chemically Pure Acids and Ammonia
Anhydrous Ammonia
Collodion and Lacquers
Nitrate of Silver
Flour Sulphur
Sulphite Soda
Liver of Sulphur
Soluble Cotton and its solvents
Ether, U. S. P. for anaesthesia

A FULL LINE OF TECHNICAL, PHOTOGRAPHIC AND MEDICINAL CHEMICALS

MAGNESIUM

The lightest commercial metal. One-third lighter than aluminum.

Magnesium bars, 99% pure.
Magnesium—Aluminum alloys.
Magnesium—Silicon alloys.
Powder in all meshes.
Magnesium—Copper alloys.
Calcium—Copper alloys.

AMERICAN MAGNESIUM CORPORATION
Niagara Falls, New York

Ferro-Uranium

The Latest Discovery in Alloys for Efficient

HIGH SPEED and other STEELS of QUALITY

Largest Producers in the World of Uranium

Write Us for Particulars

STANDARD ALLOYS COMPANY
Forbes and Meyran Avenues, Pittsburgh, Pa.

ALUMINUM,
SILICON-COPPER,
(For making solid, pure copper castings.)
Manganese Copper,
We will quote as cheerfully as we ship
Special Alloys to Order.
Experimental Work in Electro-Metallurgy.
THE ELECTRIC SMELTING AND ALUMINUM COMPANY
LOCKPORT, N. Y.

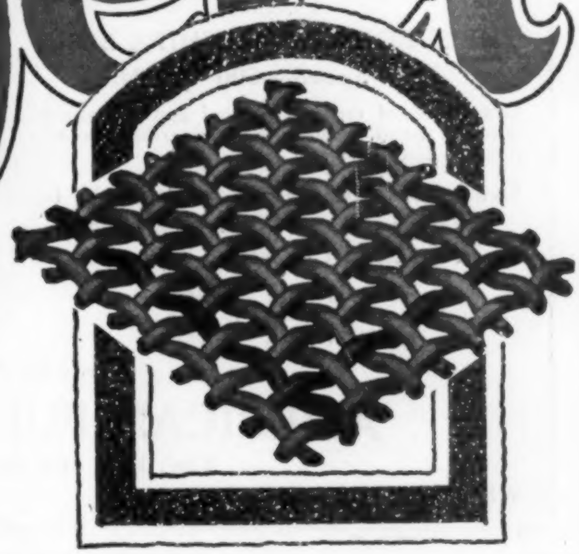
QUALITY COUNTS
SUPERFINE
METAL DUSTS

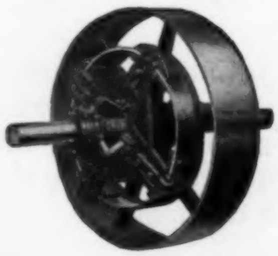
ZINC DUST

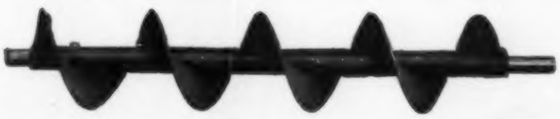
Aluminum Powder
Magnesium Powder
Tin Dust
Lead Dust

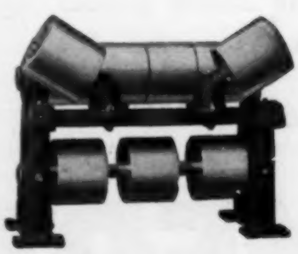
Any Mesh
Guaranteed Purity

Metals Disintegrating Co., Inc.
62 Broadway, New York Tel. Rector 662









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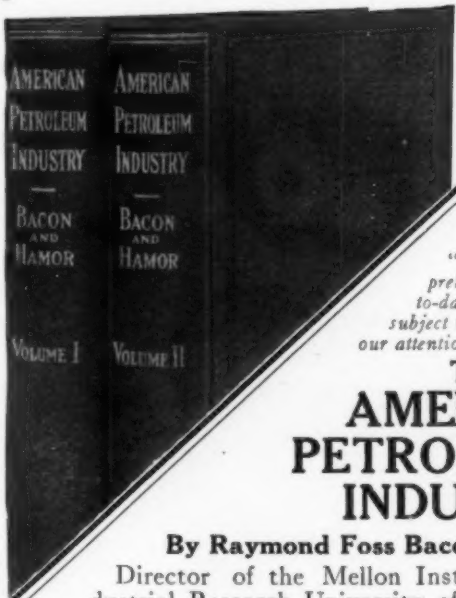

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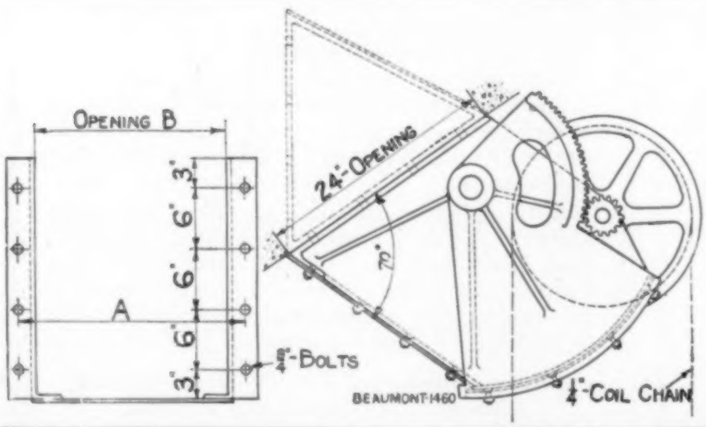

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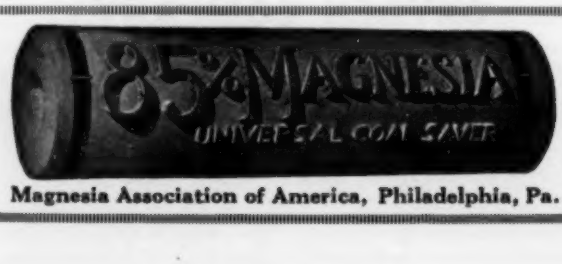

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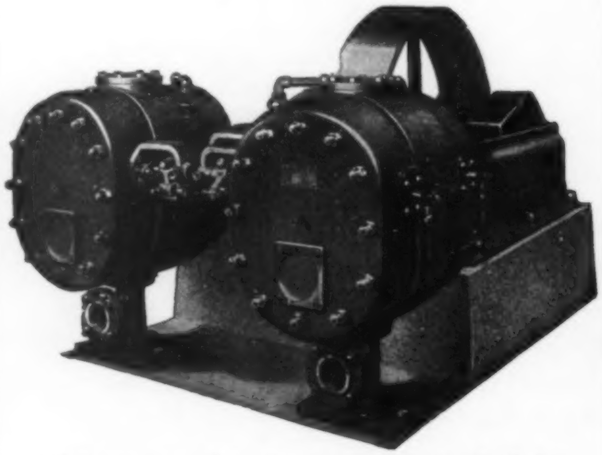

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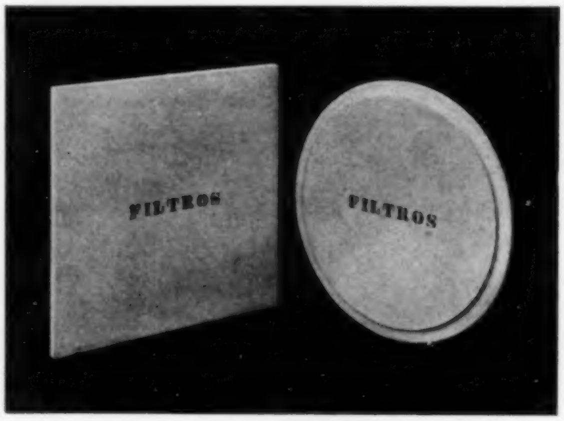

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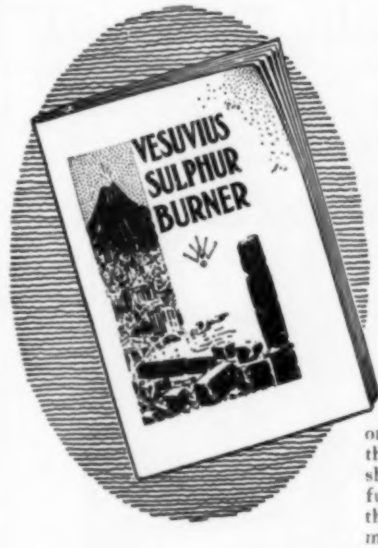

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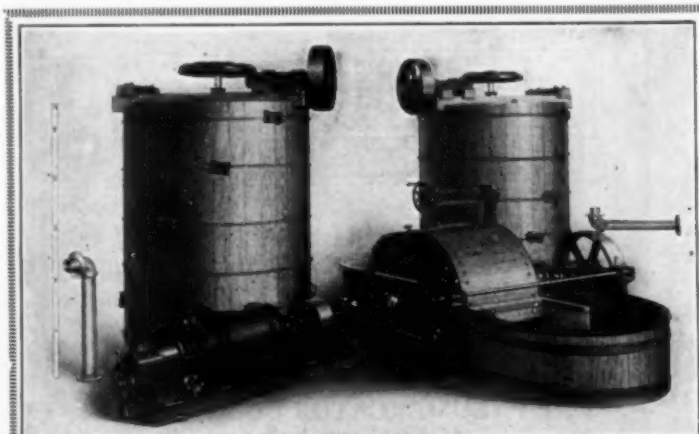

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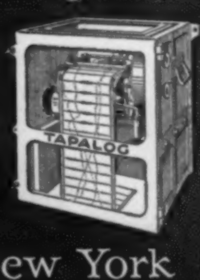

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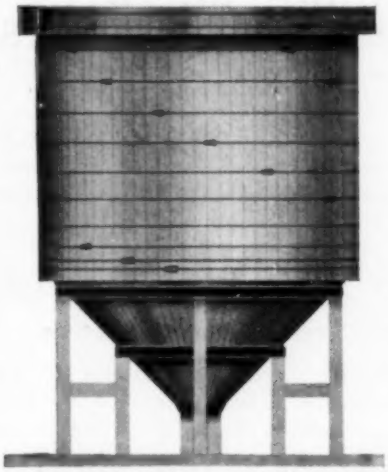

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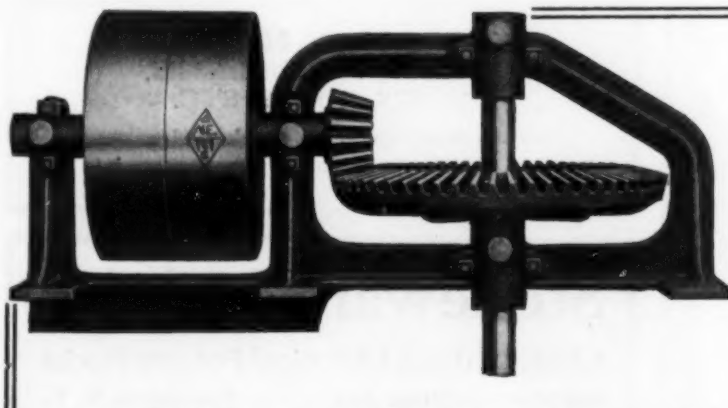

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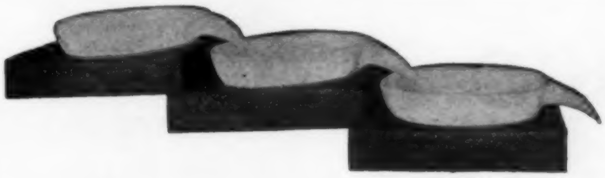


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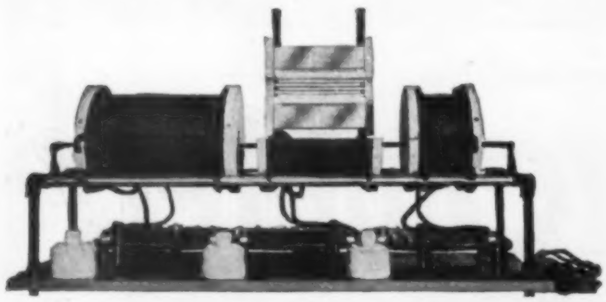

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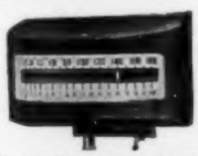

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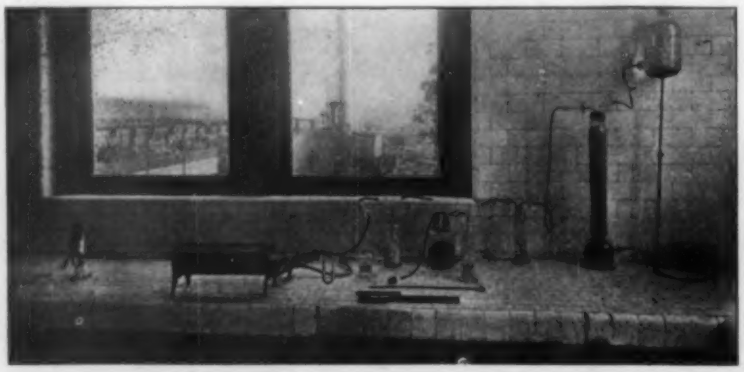

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Mines and properties examined—Advice as to development and operation—Ore treatment methods determined. Assays and analyses of all materials and products—complete, laboratories for research work.

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ADDITIONAL CARDS ON THE FOLLOWING PAGE

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(Solid, in one paragraph, without display)

THREE CENTS A WORD, minimum charge 50 cents an insertion, payable in advance, less 10 per cent, if one payment is made in advance for four continuous insertions—for advertisements under:

Positions Wanted	Vacation Work Wanted
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FIVE CENTS A WORD, minimum charge $1.50 an insertion, for advertisement under:

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THIRTY CENTS A LINE, minimum five lines, for all undisplayed advertisements set with a paragraph for each item or tabulated.

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Space for these advertisements is sold by the inch. Each page contains 30 inches. The rate per inch is based on the *total* number of inches to be used—that is, the number of inches the advertisement is to occupy multiplied by the number of insertions it is to receive. For instance, a 2-inch advertisement in 2 issues earns the 4-inch rate of $2.90 an inch. A 1-inch space in 4 issues, or a 4-inch space in one issue, also earn the 4-inch rate.

SCHEDULE OF RATES

1 to 3 in.,	$3.00 an in.	15 to 26 in.,	$2.70 an in.
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8 to 14 in.,	2.80 an in.	50 to 99 in.,	2.50 an in.

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For quick and satisfactory results tell the reader everything that he will want to know.

INFORMATION

ALLOW FIVE WORDS for the address, if replies are to a box number in care of any of our offices. There is no extra charge for forwarding replies.

IN REPLYING TO ADS, do not enclose original testimonials or anything that you may want returned. State your experience and qualifications in as concise and neat a manner as possible and enclose copies of your testimonials.

BE CAREFUL TO PUT ON ENVELOPE, when answering any "blind" ad, the box number in the ad, the name of the paper, and also the local address of office to which reply is sent:

36th St., at 10th Ave.,	New York
935 Real Estate Trust Bldg.,	Philadelphia
657 Leader-News Bldg.,	Cleveland
1570 Old Colony Bldg.,	Chicago
501 Rialto Bldg.,	San Francisco

WHEN ADVERTISING MACHINERY, use your own name and address—or a local address of some kind—so that the readers can wire direct and get quick replies. We advise also that you state in your advertisement the present location of plant that is offered for sale, or point of delivery provided you are in the market for equipment.

TO SIGN YOUR NAME and address to your advertisement begets the confidence of the reader and facilitates receiving replies. You can, however, obviate delay in receiving answers by signing your ad. only with initials (your own or others), care of your home, your office or a post-office box number in your city.

POSITIONS VACANT

EMPLOYMENT

POSITIONS WANTED

POSITIONS VACANT

CHEMIST—Knowledge of manufacture of sodium hydrosulphite by large established plant in Middle West. P-13, Chem. & Met. Engrg., Leader-News Bldg., Cleveland.

FIRST-CLASS electroplater; must have executive ability and must have had actual charge in large copper, nickel and gold plating plant; state age, education, experience and salary in first letter. P-60, Chem. & Met. Engrg.

GENERAL manager wanted for large chemical plant manufacturing soda products on Pacific Coast. It has satisfactory plant organization, but needs experience general executive, preferably one with technical knowledge. Address P-32, Chem. & Met. Engrg., Chicago.

METALLURGIST wanted, familiar with metallography, pyrometry and heat treatment of tool steels. In answering give age, training, experience and salary desired. P-70, Chem. & Met. Engrg., Philadelphia.

PROCESS control chemist wanted, or thoroughly practical dye worker familiar with H-acid colors; good opening for the right man; state all particulars, giving past experience, references, salary expected, etc.; references will not be consulted without permission of applicant. Location in the Middle West. P-69, Chem. & Met. Engrg., Chicago.

TIN metallurgist, capable of operating electric furnace plant; state experience, salary, and date available in first letter. P-61, Chem. & Met. Engrg.

TECHNICAL graduate wanted, capable of undertaking research work in metallography dealing with non-ferrous metals. Applicants should possess a theoretical knowledge of metallography as well as a knowledge of electric furnaces. Experiments will be conducted at a Canadian University. Salary $200.00 per month. Apply P-71, Chem. & Met. Engrg.

EMPLOYMENT AGENCIES

Employment Service

THE undersigned provides a confidential service designed to locate openings through correspondence for men earning not less than $2,500 and up to $25,000; all lines. Not an employment agency, but a constructive, initiative service, covering individual negotiations. Established 1910. Complete privacy assured; present connections in no way jeopardized. Send name and address only for explanatory details. R. W. Bixby, 310 Lockwood Bldg., Buffalo, New York.

POSITIONS WANTED

CHEMIST, (40), A. B., M. D. Twenty years' experience in research, past two years as head research chemist in glue at large factory, desires position in industry offering permanent location. Research, analysis or factory methods. Would prefer investigation in animal products or foods. PW-73, Chem. & Met. Engrg.

CHEMICAL engineer, University graduate, married; 6 months' experience in laboratory; two years as foreman in heavy chemical plant; three years as superintendent and chemist for ferro-alloy plant; desires position; preferably in Philadelphia district, at reasonable salary. PW-62, Chem. & Met. Engrg., Philadelphia.

PRACTICAL research chemist, over six years' experience in boiling and processing of drying and semidrying oils and substitutes, varnishes, gums, resins, driers; development of special purpose sizings, adhesives, waterproofings and coatings for textiles; nitrocellulose coattings and solvents; numerous related materials; employed at present, but want executive position with opportunities. PW-64, Chem. & Met. Engrg., Philadelphia.

POSITIONS WANTED

B.S., 22, Eastern College, honorably discharged from service, desires opening as chemist's assistant where he can put his thorough training of chemistry to the best use of employer. PW-985, Chem. & Met. Engrg.

CHEMICAL engineer, 26, graduate, at present employed, desires to change position; four years' experience in the manufacture of acids, inorganic salts, intermediates. Executive ability. P. O. Box 305, Wilmington, Del.

CHEMICAL and Metallurgical Engineer—Position as executive. Chief chemist or superintendent, 8 years chief chemist and superintendent acid plant and smelters. Experience in iron and steel, zinc, copper, ferrous and non-ferrous alloys. Presently employed by large copper company. Draft exempt. PW-522, Chem. & Met. Engrg., San Francisco.

CHEMIST (24), technical graduate, with 5 years' varied analytical and factory experience, desires new responsible connection; proficient, reliable; minimum salary, $2400. PW-39, Chem. & Met. Engrg.

CHEMIST, University graduate with four years of industrial experience along metallurgical, analytical, electro-chemical and microscopical lines. Recently discharged from chemical warfare service; 28 years old; married; desires position on original research or industrial research along the above lines. PW-23 Chem. & Met. Engrg., Philadelphia.

CHEMIST, university graduate, qualified by civil service and experienced in general analytical and factory work as assistant and chief, seeks position N. Y. City or commuting distance. F. S. H., Ph. B., 215 Schermerhorn St., Brooklyn.

CHEMIST, 35; German University graduate, capable of doing organic research on aromatic synthetics, wants position. Address PW-55, Chem. & Met. Engrg., San Francisco, Calif.

Still-House Foreman

For 200 Cord Hardwood Distillation Plant

Manufacturing crude wood alcohol and acetate of lime. One of the largest, most modern plants in the United States. Exceptional opportunity for man experienced in handling similar still-house operations. Write fully, giving previous experience, references, salary expected and when available. Address

P77—Chem. & Met. Engineering
1570 Old Colony Bldg., Chicago, Ill.

WANTED

Pharmaceutical Chemist

thoroughly familiar with one or several processes for manufacturing pharmaceutical or other fine chemicals wanted. Liberal share of profits assured. State products you can manufacture, manufacturing price and investment required.

P78 Chem. and Met. Engineering
10th Ave at 30th St., New York City

WANTED

A Chemical Engineer

Technical graduate as assistant superintendent of chemical plant. A young man about 26 years of age who has had plant experience and can handle men. Available about July 1st.

Address letter giving full details of training, experience, salary expected and references to Manufactures, P. O. Box 886, Pittsburgh, Pa.

EMPLOYERS

Send us your inquiries for men of technical training and experience. We are obtaining employment for soldiers, sailors and marines released from the service.
Re-Employment Bureau of New York City for Soldiers, Sailors and Marines, 505 Pearl Street, north of Municipal Building, Professional Section. Worth 9250.

Little "WANT" cards bring big results in Chem. & Met. Eng.

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be careful to put on envelope the key number in the ad. and also local address of office to which reply is sent.

10th Ave. at 36th St., New York.
935 Real Estate Trust Bldg., Phila.
657 Leader-News Bldg., Cleveland.
1570 Old Colony Bldg., Chicago.
501 Rialto Bldg., San Francisco.

Important

Original letters of recommendation or other papers of value should not be enclosed to unknown correspondents—send copies.

POSITIONS WANTED

CHEMIST, French; speaks English; 31 years old; graduate Societe Industrielle de St. Quentin; versed in the manufacture of sugar, alcohol, organic nitrates, and chlorine derivatives, particularly dinitrochlor-benzol and carbon tetrachloride; desires permanent situation in America. Address M. Boulogne, Ingenieur Chemist, Hotel Moderne, Moutiers (Savoie) France.

CHEMIST and metallographist; recently released from government service, desires to make connections. Thoroughly capable young man, graduate chemist, with good knowledge of heat treatment, and wide commercial laboratory and steel plant experience. Address PW-72, Chem. & Met. Engrg.

CHEMICAL engineer, 29 years old; B. S. and M. S. Mass. Inst. Technology; 3 years' practical machine shop work and 4 years' experience in manufacture of coal-tar products, such as creosote stains, lamp black, napthalene, disinfectants, tar-paper, etc. Desires position for plant control and plant research or development of machinery and processes. Location, United States or Canada. Address W. W. Lang, 33 Fairview Street, Roslindale, Mass.

ELECTRICAL engineer, thoroughly experienced purchasing equipment; designing medium voltage. Alternating current distrbution systems PW-85, Chem. & Met. Engrg.

Works Manager

engineer, with 20 years of broad business training in factory management and production methods. Lately general manager of large manufacturing plant in middle west. Experience has covered plants devoted to metal products. Highest credentials.

Address H. R. G., Room 708,
115 Broadway, New York City.

Western Executive Connection

wanted by man experienced in chemical and production engineering, factory organization and management. Age 36; salary, $5000.
PW74—Chem. & Met. Engr.
1570 Old Colony Bldg., Chicago

Chemical Engineers
Plant Supts.
Mill Supts.
Chemists
Assayers
Metallurgists
Draftsmen
Mill Shift Bosses

POSITIONS WANTED

CHIEF chemist and metallurgist now connected with large steel foundry; practical experience in the analysis of all steel works materials and working knowledge of metallurgy of iron and steel; married, of good habits, desires change. PW-63, Chem. & Met. Engrg., Philadelphia.

ELECTROCHEMICAL engineer, graduate Massachusetts Institute of Technology; one year in charge electric reduction furnace; 15 months plant control and operation large paper-mill; comeptent handling men; now in charge of laboratory; desires change. PW-35, Chem. & Met. Engrg.

METALLURGICAL and chemical engineer, 12 years' experience, desires position. Chief chemist in largest smelting laboratory in West. Operating experience covers blast furnace, roaster, reverberatory smelting of copper and electrical precipitation of copper and zinc dusts. Technical graduate. Highest references. PW-987, Chem. & Met. Engrg.

PLANT executive; experienced executive with engineering training and wide experience in celluloid and heavy chemicals desires connection with established manufacturer who intends to extend lines of activity in chemical industry. Interested if position worth $8000 and up. PW-82, Chem. & Met. Engrg.

RECENT graduate in chemical engineering with experience in metallurgical and pharmaceutical lines desires position where his knowledge can be used to advantage. Willing to start low if chance for advancement is good. George Cramer, 1123 Clay Ave., Bronx, N. Y.

TECHNICALLY trained young man, age 26, American; one year practical experience in laboratory, two years as assistant superintendent chemical plant, desires position in operating department of plant; can handle men and take care of chemical and mechanical details; highest references. PW-65, Chem. & Met. Engrg.

YOUNG man, 31 years of age, married and a graduate chemist, with four years' manufacturing experience, desires to get in touch with party desiring high-class man. Have had considerable executive experience and can handle men. PW-86, Chem. & Met. Engrg., Philadelphia.

EXPERIENCED steel chemist desires connections with steel plant or factory. Can take charge of laboratory. PW-84 Chem. & Met. Engrg.

MECHANICAL engineer, graduate, ten years' experience, designing construction, operation and estimating of chemical plants, gas plants and furnaces, including experiemntal and research work. Employed, reason for desiring change—probable lack of work owing to cancelling war work. Prefer permanent position desgning and construction. Married. Phil. dis. preferred. PW-44, Chem. & Met. Engrg., Philadelphia.

VACATION WORK WANTED

Chemical Engineer Wants Vacation Work 21, single, senior standing in one of leading universities, analytical experience, desires position with executive, advertising, sales or research department. Two years' experience as salesman. Good references. Open for engagement, June 21. M. J. Pearce, 108 E. Daniel St., Champaign, Ill.

CHEMIST

12 years' executive manufacturing, consulting, research experience; problems of management, development, installation of new organic process; improvement of processes in operation; linguist; Ph.D.; highest references.

M 76—Chem. & Met. Engr.
10th Ave. at 36th St., New York City

Business Opportunities

Capital—Partners—Plants—Shops—Properties—Industrial Sites

BUSINESS OPPORTUNITY

New Patented Process for Smelting
of manganese and iron ores. Correspondence invited with parties who can finance experimental work on new process for production of ferro-manganese, pig iron, and ferro-silicon. This is not an electric furnace process. BO-68, Chem. & Met. Engrg., Rialto Bldg., San Francisco.

Opportunity for Progressive American Firm
Well-known English firm or chemical engineers with large experience in the manufacture of special fans for acid gases in connection with chemical works, also in the construction of acid elevators of automatic type, are looking for up-to-date American firm who could manufacture and sell these appliances under royalty and commission; complete detail drawings and all information being supplied. Any thoroughly progressive firm interested please reply. BO-80, Chem. & Met. Engrg., 6 Bonverie St., London, E. C. 4.

BUSINESS OPPORTUNITIES

Attention—Consulting Engineers
An experienced industrial and chemical engineer desires to become associated with an established firm of engineers to take charge of department preferably of profit-sharing basis. BO-81, Chem. & Met. Engrg.

100-Acre Rutile Property
FOR SALE IN FEE
Probably best undeveloped deposit in United States. Located in Nelson County, Virginia, rutile district, one mile from railroad with large stream of water on property. Open cut mining, now partially developed by crosscuts and trenches. Terms reasonable. Write at once to
J. H. WATKINS
105 Hammond Court, Washington, D. C.

BUSINESS OPPORTUNITIES

Capital Wanted
To obtain foreign patents on an invention which should be of great interest and value in all coal producing countries. The invention relates to a motor fuel of an unusual type, made from coal. Address BO-82, Chem. & Met. Engrg., Phila.

Waterway in Norway
at excellent harbor in Western part of Norway. Up to 20,000-kw. to be let now. Any voltage and current supplied. Excellent grounds and facilities. Waterfalls in different parts of Norway—3000 to 200,000-H.P. available. Apply
Det Tekniske Finansinstitut a.s.
Kristiania, Norway

Selling Opportunities

Salesmen — Agents — Representatives

SALESMEN WANTED

Sales Engineer Wanted
Familiar with evaporating apparatus. Chance to connect with first-class concern. In your application, state your age, experience and salary expected. All information will be treated strictly confidential. AS-721, Chem. & Met. Engrg., Chicago.

SALESMEN AVAILABLE

High-class Specialty Salesman
Graduate engineer with broad chemical, mechanical and electrical experience desires connection with a manufacturer to represent him. Northern Ohio and Michigan territory preferred. Address AS-53, Chem. & Met. Engrg., Cleveland.

Sales Position Wanted
Experienced technical graduate, with technical and practical knowledge of chemical machinery and apparatus desires sales position with manufacturer of chemical equipment. AS-87, Chem. & Met. Engrg.

SALESMAN WANTED
Experienced in thin wall steel tubing and having a clientele among tubing users—must be first class man. Make application in own hand writing with references and experience.
AS 900—Chem. & Met. Eng.
10th Ave. at 36th St., New York

AGENCIES AVAILABLE

Domestic

Do You Want New York and Export Agent?
Two experienced supervising and sales engineers, with offices in New York, want one or two good sales accounts for eastern territory and export business; preferably to represent western or southern manufacturers. Only very high-grade connections will be considered. AS-29, Chem. & Met. Engrg.

AGENTS WANTED

Manufacturer's Agents Wanted
to handle chemical and engineering mechanical specialty; state experience and references. AS-66, Chem. & Met. Engrg

Sales Representatives Wanted
Mechanical men wanted in all towns over 5000, to sell in their spare time and on a commission basis, iron, steel and brass castings, forgings, structural and sheet work, machinery and tractor repairs for a group of engineering shops located in different parts of the country. This will not interfere with your present employment. AS-67, Chem. & Met. Engrg., Chicago.

Broker and Commission Merchant
DESIRES TO REPRESENT
Eastern manufacturers of chemicals on Pacific Coast and in Hawaiian Islands.
J. F. C. HAGENS
58 Sutter Street, San Francisco, California

AGENCIES WANTED in France for Chemical Products
Address: DANIEL T. PIERCE
(U. S. Representative, Société Francaise d' Action Economique Paris), 149 Broadway, New York.

EXPORT—IMPORT
Executive manufacturing chemist, American citizen, 14 years' industrial experience in chemicals, pharmaceuticals, dyestuffs, oils, etc., in Asia, Europe, Russia, America, college graduate, linguist, desires connection with export-import house; moderate remuneration to start; would go abroad; highest references.
AS 75—Chem. & Met. Engr.
10th Ave. at 36th St., New York City

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advertising of this industry.

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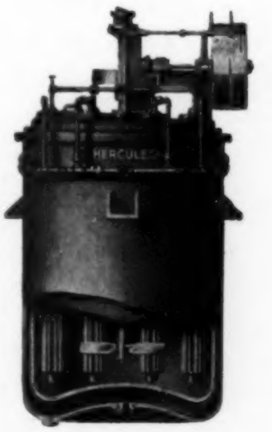

TWO (2) NEW NITRATORS, 4 ft. inside diameter, 5 ft. 6 in. inside height. Capacity 500 gallons each. Cast iron jackets and vertical cast iron tubes for cooling and temperature control. Agitators, cut gears, tight and loose pulleys.

TWO (2) NEW AUTOCLAVES, 38 in. inside diameter, 69 in. inside of pot. Capacity 300 gallons each; internal working pressure 500 pounds. Without jackets—for direct firing. Horse-shoe agitator, cut gears, tight and loose pulleys. Pot and cover made of semi-steel.

TWO (2) NEW SULPHONATORS, 3 ft. 5 in. inside diameter, 6 ft. 4 in. inside height. Capacity 400 gallons each. Arranged for direct firing. Agitator, cut gears, tight and loose pulleys.

1—DEVINE ROTARY VACUUM DRYER, 5 ft. 0 in. diameter x 25 ft. 0 in. long, steam jacketed with complete driving equipment, surface condenser, catch-all and vacuum pump. Excellent condition. Used for reclaiming of rubber scrap.

5—BUFFALO FOUNDRY MACHINE COMPANY'S ATMOSPHERIC DRUM DRYERS (C. C. 1219), 5 ft. 0 in. x 11 ft. 9 in. long. Drums 1½ in. thick. Will stand 50-lb. steam pressure. Complete equipment including Buffalo Foundry patented feeding device, scraping knives, reduction gearing and tight and loose pulleys. A tank and two troughs are included with this equipment under each scraping knife for collecting the dry material.

2—PASSBURG-DEVINE VACUUM SHELF DRYERS (T. P. 521), each 1150 sq. ft. heating surface, 17 shelves, tested for 90-lb. pressure condenser, trays, truck pump, complete.

1—RUGGLES COLES DIRECT HEAT DRUM DRYER (T. P. 876-C), drum 5 ft. diameter x 30 ft. long, with blower and tight pulley, cast iron furnace fittings, etc. Outfit has sheet steel front with breaching and spout.

1—BUFFALO FOUNDRY ROTARY VACUUM DRYER (T. P. 1092), 2 ft. 0 in. diameter x 4 ft. 0 in. long. Complete machine without vacuum pump. Brand new, used but 30 days.

1—BUFFALO FOUNDRY AUTOCLAVE (T. P. 405-C), 2 ft. 0 in. diameter, 3 ft. 6 in. deep, fitted with plug cock for 700-lb. ammonia pressure; capacity 67 gallons.

1—BUFFALO FOUNDRY AUTOCLAVE (T. P. 405-D), 2 ft. 0 in. diameter, 3 ft. 6 in. deep, 67 gallons capacity, 700-lb. ammonia pressure. Has provision for stirring device but not equipped with frame.

12—WATSON CENTRIFUGALS (T. P. 922-A), under-driven 42 in. diameter steel baskets, 17 in. deep, no discharge, aluminum hinge covers. Speed 900 r.p.m. New bronze bearings, shafts and baskets will be furnished.

1—CAST IRON VACUUM PAN, 33 in. diameter x 48 in. deep, steam jacketed, complete with manhole, bottom discharge, necessary openings. This machine new, not furnished with condenser or pump.

1—54 IN. DIAMETER HARRIS COPPER VACUUM PAN, steam jacketed for either live or exhaust steam, equipped with stirring apparatus. Complete equipment with jet condenser. No pump. Suitable for new products, extracts, soups, etc.

12—ROTREX VACUUM PUMPS, 14 x 28, displacement of 243 cu. ft. per minute. Direct connected to a 6 x 6 vertical, enclosed throttling governor engine. New equipment. Immediate delivery.

4—WHEELER SURFACE CONDENSERS, 42 in. x 9 ft. 2 in. long containing 1369 ⅝-in. brass tubes and heads. All other fittings of brass. New condensers. Immediate delivery.

8—WERNER & PFLEIDERER MIXERS, size 15, type VI, class B.B. tilting type, jacketed cast iron trough, air tight cover; complete with pulleys, necessary driving mechanism. Capacity 100 gallons.

6—SHRIVER WOODEN FILTER PRESSES, 36 x 36 with seventeen to thirty-one chambers 2 in. thick, capacity ranging from 16 to 29 cu. ft. All in excellent condition. Available for immediate delivery.

1—36 x 36 PROVOST WOODEN FILTER PRESS, with 24 chambers forming 3-in. cakes. Corner feed, open delivery, non-washing type.

1—No. 6 ABBE PEBBLE MILL, size 30 in. diameter x 30 in. wide, complete with pulleys and supporting frames. Very good condition.

1—No. 8 ABBE PEBBLE MILL, 18 in. diameter x 27 in. long with manhole on one side and drawing-off plug on the other. Excellent condition.

1—PEBBLE MILL, made by the Patterson Foundry & Machine Co., 53 in. outside diameter x 6 ft. 3 in. long, type "B." Condition excellent, used only few weeks.

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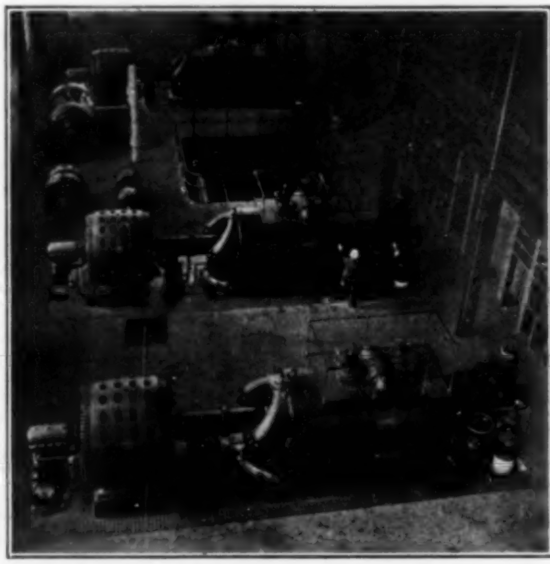

A.C. Turbine Generator Sets

3—2000-kva., 3-phase, 60-cycle, 6600/4000-volt, 1200-r.p.m. Westinghouse-Parsons Horizontal Turbines and Generators, complete with switchboards, exciters and Alberger 8000-sq. ft. surface condenser, with auxiliary pumps. Stirling Boilers are also available. Complete plant equipment can be shipped immediately.

4—**Complete Engine Generator Sets,** each unit consisting of a

60-kw., 120-volt, direct current Ft. Wayne Wood System Generator, direct connected to a Chandler & Taylor horizontal 13 x 13 slide valve steam engine, operating at 240 r.p.m. on 100 lb. steam pressure.

Included with the above sets are:

4—Generator Panels, with the usual meter equipment and circuit breakers and switches on them. All four units are in first class condition and are available for immediate delivery. These outfits are subject to inspection.

MOTORS

3-Ph., 60-Cy., 220-Volt and 440-Volt Motors

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1	1	G. E.	K.	600/1800	U.	Stock
2	2	Howell	S.C.	1800	New	Stock
1	3	Howell	S.C.	1800	New	Stock
1	3	Triumph	S.C.	1800	Used	Stock
1	5	A.C.	AN.	1200	New	Stock
2	7½	Howell	S.C.	1200	Used	Stock
3	7½	Wh.	C.S.	1800	New	Stock
1	7½	Wh.	H.F.	1200	Used	Stock
1	15	Wag.	Elev.	1200	Used	Stock
1	20	Wh.	C.W.	1200	New	Stock
4	20	A.C.	ANY	1200	New	Stock
7	20	F.-M.	KBV.	1200	New	Stock

No.	H.P.	Make	Type	R.P.M.		Avail
1	20	G.E.	M.	600	Used	Stock
1	25	Wh.	C.S.	1200	New	Stock
2	50	A.C.	AN.	720	New	Stock
2	75	A.C.	AN.	900	New	Stock
1	75	Wh.	C.-W.	900	New	Stock
1	100	Wh.	C.S.	900	New	Stock
1	100	Wh.	C.W.	720	New	Stock
4	150	Wh.	C.W.	720	New	Stock
2	150	Wh.	C.W.	600	New	Stock
1	150	Wh.	C.W.	900	New	Stock
5	200	Wh.	C.W.	720	New	Stock
4	200	Wh.	C.W.	600	New	Stock

Our stock includes a large number of Auto-Starters and Resistance Starter, for squirrel cage Motors. Also Drum Type and Face Plate Type for Slip Ring Motors.

3-Ph., 60-Cy., 550-Volt Motors

No.	Hp.	Make	Type	R.p.m.		Avail.
6	15	Wh.	C.S.	1800	New	Stock
1	75	G. E.	M.	514	Used	Stock
1	75	Wh.	C.W.	900	New	Stock
1	150	Wh.	H.F.	600	Used	Stock
1	150	W. E.	M.	600	New	Stock
3	150	Wh.	C.W.	600	New	Stock
2	200	Wh.	C.W.	600	New	Stock
1	200	W. E.	M. 3 Brg.	600	New	Stock

3-Ph., 60-Cy., 2200-Volt Motors

No.	Hp.	Make	Type	R.p.m.		Avail
1	75	A. C.	ANY	720	New	Stock
2	75	Wh.	C.W.	900	New	Stock
1	75	G. E.	M.	514	Used	Stock
1	100	Wh.	C.W.	900	New	Stock
1	150	Wh.	H.F.	600	Used	Stock
1	150	W. E.	M.	600	New	Stock
2	150	Wh.	C.W.	600	New	Stock
3	150	Wh.	C.W.	720	New	Stock
1	200	W. E.	M. 3 Brg.	600	New	Stock
2	200	Wh.	C.W.	600	New	Stock

3-Ph., 25-Cy., 550-Volt Motors

No.	Hp.	Make	Type	R.p.m.		Avail.
1	30	A.C.	A.N.	750	Used	Stock

3-Ph., 25-Cy., 220- and 440-Volt Motors

No.	Hp.	Make	Type	R.p.m.		Avail
1	1	Westg.	CSA	750	New	Stock
1	2	Wh.	C.S.	1500	Used	Stock
3	2	A.-C.	A.N.	750	New	Stock
1	3½	Burke	C.S.	1500	Used	Stock
1	5	W. E.	K.	750	New	Stock
3	5	A.-C.	A.N.	750	New	Stock
1	7½	A.-C.	A.N.	750	New	Stock
1	7½	G. E.	M.	750	Used	Stock
4	10	A.-C.	A.N.	750	New	Stock
1	15	W. E.	K.	750	New	Stock
1	15	A.C.	AN	1500	Used	Stock
2	20	W. E.	K.	750	New	Stock
5	30	W. E.	K.	750	New	Stock
3	30	A.-C.	A.N.	750	New	Stock
4	40	W. E.	K.T.	750	New	Stock
3	40	A.-C.	A.N.	750	New	Stock
5	50	W. E.	K.	750	New	Stock
4	50	A.-C.	A.N.	750	New	Stock
2	75	Wh.	C.S.	750	New	Stock
1	75	W.E.	K.	1500	New	Stock
1	100	W.E.	K.	1500	New	Stock
1	150	A.-C.	ANY	500	New	Stock
1	150	W. E.	K.	750	New	Stock
2	150	W. E.	M.	750	New	Stock
2	150	W. E.	M.	500	New	Stock

2-Ph., 60-Cy., 220-Volt Motors

1	2	G. E.	K.Q.	1200	Used	Stock
1	10	W.	H.F.	1200	Used	Stock

Single-Phase, 60-Cy. Motors

No.	Hp.	Make	Type	Volts	R.P.M.	Avail.
1	¼	W.H.	A.R.	110-220	1800	N 7-15
1	¼	W.H.	A.R.	110-220	1200	N S-W
1	1	W.H.	A.R.	110-220	1800	N 5-30
1		W.H.	A'R.	110-220	1200	N 8 W
1	2	Wag.	B.A.	110-220	1200	U Stk
1	2	W.H.	A.R.	110-220	1800	N 7-15
1	2	W.H.	A.R.	110-220	1200	N 5-15
1	3	W.H.	A.R.	110 220	1200	N 7-15
1	5	W.H.	A.R.	110-220	1800	N 7 30
1	5	W.H.	A.R.	110-220	1200	N 6-15
1	5	Wag.	B.A.	110-220	900	U Stk
1	5	Wag	Elev.	220	900	U Stk.
1	7½	Wag.	B.A.	110-220	1200	U S-R

110-Volt D.C. Motors

No.	Hp.	Make	Type	Fld.	R.p.m	Avail.
22	1/16	R & M		Sh	900	U Stk
1	1	Wh.	R	Sh.	1800	U Stk
1	1½	Diehl	G	Sh	1180	U Stk
1	15	R. & M.		Cpd.	1050	U Stk
1	40	Wh.	M	Sh.	950	U Stk
1	60	Wh.	S.A.	Sh.	1000	U Stk

220-Volt, D.C. Motors

No.	H.P.	Make	Type	Fld.	rpm.	Avail
1	½	W.H.		Sh	1140	U St.
1	2	New Eng.	E.	Sh	800	U St.
1	3	Triumph		Sh.	1000	U St.
1	3	W.H.	S.	Sh.	1800	U St.
1	3	W.H.	S.	Sh.	2000	U St
1	4	W.E.	D.F.	Sh.	1700	U St
1	7½	G.E.	Var. Spd.	Cpd.	450/900	U St.
1	7½	C.E	C.A.	Sh.	1525	U St.
1	10	W.H.	N	Sh.	1250	U St.
1	15	W.H.	S.	Sh.	725	U St.
1	20	Ft. Wayne	B-1	El. Cpd.	820	U St.
1	25	G.E.	C.L.	Sh.	675	U St.

Belted D.C. Generators

No.	Kw.	Make	Type	Vlt.	Rpm.	Avail.
1	1.8	F.-M.	T.R.	110	2350	U Stock
1	10	Wh. S.	Cpd.	250	1325	U Stock

Chain Drives

Link Belt Silent Chain Drive

1—Flanged Steel Pinion, 4.987-in. diam., 25 teeth, ¾-in. pitch, 1 3/16-in. bore, ½ x ¼-in. K.S. tapered to ¾-in.

1—Flanged C. I. Wheel, 11.942-in. diam., 60 teeth, ¾-in. pitch, 1 3/16-in. bore, ½ x ¼-in. K.S., tapered to ¾ in., CL to CL of drive, 16 in.

This Chain Drive is complete and has never been used. It is in our stock due to change in the plans of the job for which it was ordered.

D.C. Turbine Generator Sets, 125-Volts

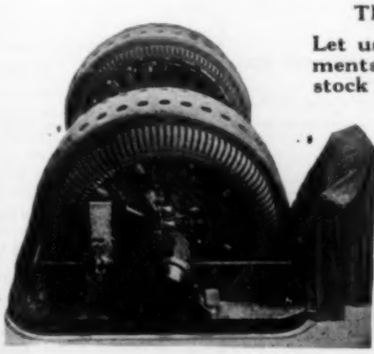
Pinion and Gear

1—Spur Gear 1½ D.P., 2.0944-in. C.P 6-in. face, 56 teeth, 37-33. in. P.D., 4/-in. bore, 1¼-in. x ¾-in. keyway, complete with Shaft and Bearing for bolting to pedestal foundation.

1—Pinion 1½ D.P., 2. 944-in. C.P., 6-in. face, 23 teeth, 15.33-in. P.D., 4½-in. bore, 1¼-in. x ¾-in. keyway. Gear ratio 2.4 to 1. 125 hp. at 514 r.p.m.

TRANSFORMERS

Let us know your requirements as we have a large stock available.



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25-60 Cycles 4000 Kva. capacity complete and available for early delivery.

Meeting the Emergency Is Standard Practice

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SURPLUS MATERIAL AND EQUIPMENT

All classes of ship construction and Shipyard Plant Construction equipment and material including large quantities of

- Wood Working Machinery
- Machine Tools and Fixtures
- Electrical Machinery
- Boiler Shop Equipment
- Forge Shop Equipment
- Marine Equipment and Accessories
- Air Compressor Equipment
- Contractors Equipment and Supplies
- Bridge and Gantry Cranes
- Steel Plates, Shapes and Bars
- Pumping Machinery
- Scrap Metals
- Lumber
- Deck Equipment
- Galley Equipment

All parties interested in the purchase of any of the foregoing classes of material will receive formal invitations to bid periodically as the material is available if they will promptly request that their names be placed on mailing lists for the items in which they are interested.

SALVAGE—UNITED STATES SHIPPING BOARD EMERGENCY FLEET CORPORATION
140 North Broad Street, Philadelphia, Penna.

HEATERS

1—1300-hp. Blake Heater.
1—1300-hp. Berryman Heater.
1—200-hp. Reilly Multicoil Heater.
1—200-hp. Berryman Heater.
1—1000-hp. Wheeler Condenser.

TANKS

1—400,000-gal. Open Tank.
Lot of open and closed Steel Tanks.
All sizes of Tanks, open and closed, suitable for storage of gasoline, or fuel oil, in stock at our Boston yard.

CHEMICAL EQUIPMENT

2—**Phenol Stills**, 44 in. dia. x 4 ft. 2 in. deep.
1—**Jacketed Vacuum Still**, 6 ft. 6 in. dia. x 6 ft. deep with agitation and condenser tank.
1—**Nitrating Kettle** (with agitator), 4 ft. 2 in. deep x 3 ft. 8 in. dia.
2—**Cast Iron Kettles**, 35 in. dia. x 36 in. deep.
6—**Steel Jacketed Plates.**
2—**Quenching or Dissolving Kettles**, 6 ft. 6 in. dia. x 6 ft. 6 in. deep.
1—**Fusion Kettle** (with agitator), equipped with oil burners.
1—**Rotary Dryer**, 4 ft. 3 in. dia. x 19 ft. long, made by J. P. Devine of Buffalo, N. Y.
1—**New Rectifying Column or Benzol Still**, 32 in. x 26 ft. 8 in. long (with still 6 ft. 6 in. deep x 8 ft. 2 in. dia.).
2—**Steel Condensers**, 42 in. dia. x 42 in. deep, with Iron Pipe Coil.
1—**Galvanized Air Tank**, 30 in. dia. x 6 ft. long (dished heads), 5/16-in. plate.
1—**Receiving Tank**, 5 ft. in dia. x 10 ft. high.
2—**Galvanized Phenol Receiving Tanks**, 3 ft. dia. x 5 ft. long.
Several **Worthington Duplex Pumps.**

BOILERS

6—Manning Vertical Boilers, 185 hp. 120 lb. pressure.
2—Erie City Water Tube Boilers, 400-hp. each.
1—Stirling Boiler, 250 hp.
1—Franklin 500-hp. Water Tube.
1—Mass. Standard, 72-in. Horizontal Return Tubular.
1—Mass. Standard 66-in. Horizontal Return Tubular.

Also Vertical Types in Stock

THE PERRY, BUXTON, DOANE CO.
214 W. First St., S. Boston, Mass.

BREWERY EQUIPMENT FOR SALE

Consisting of Nothing Over Six Years Old

A 25 Kw. **Generator set, Crocker-Wheeler**, 125 volts, 200 amperes, 325 r.p.m., direct connected to a Fitchburg side crank **engine**, complete with switchboard—can be seen running.

A 40-ton **refrigerating machine**, horizontal heavy duty frame, Wolff make, direct connected to a Watts & Campbell Corliss engine, four stacks of good ammonia condensers, atmospheric type, complete high pressure side. 200 barrel copper Brew kettle, will sell all or part of it. Double pipe Dockbach copper beer (for Brine) cooler. All sizes of copper pipe at 22c. per pound. All sizes of good brass valves at 40c. per pound. 16 Worthington pumps, sizes from 6 x 4 x 6 up. Also some pressure pumps. Worthington Air compressor. Good heavy Brewer's hose, with couplings at 25c. per foot.

3 ft. x 4 ft. **copper tanks** at 25c. per pound. Also same sizes **Fiber tanks.**

A complete **rice cooker or digestor**, with stirring device. A complete modern **Malt mill** with hopper and scale. A lot of 4 in. link belt, silent chain complete with gears 30 ft. or 40 ft. A lot of wooden tanks 12 x 12 and 10 ft. in diameter x 14 ft. high at $100.00 each f.o.b. cars New York City.

All must be removed within 30 days and prices upon application will be very inviting. Address A. M. Stadler, c/o W. A. Miles & Company, Brewery, 390 Cherry Street, New York City. Salesman on job all day long or address me at 405 Lexington Avenue, New York City; 'phone Murray Hill 4375.

WELDED STEEL SHIPPING **BARRELS** TANKS DRUMS

LIGHT SHEET METAL PRODUCTS AND REPAIRING

CARBONDALE WELDING CO. **CARBONDALE, PA.**

For Sale at once

WESTINGHOUSE TRANSFORMERS

3—37½-kva., single-phase, 60-cycle, 22,000 volts, primary, 220 volts secondary.

1—15-kva., single-phase, 60-cycle, 22,000 volts primary, 220 secondary.

LINN GROVE LIGHT & POWER CO.
Linn Grove, Ind.

FOR SALE

Equipment of Electrolytic Zinc Plant

including **Wood Tanks** of various sizes, **Agitator and Dorr Mechanisms, Portland Filters, Filter Presses, centrifugal** and **triplex Pumps, Air Compressors,** wet and dry **Vacuum Pumps, Shafting, Pulleys, etc.**

Detail list on application.

RIVER SMELTING & REFINING CO.
Keokuk, Iowa

BOILER SNAP

4—225 H.P. 84 in. x 20 ft. tubular boilers 125 lb. steam with chain grate stoker. Like new.

Ask stock list of 1000 machinery bargains.

WICKES MACHINERY CO.
Jersey City, N. J.

TANKS

FOR SALE

100 to 20,000 gals.

Immediate Shipment

PEERLESS IRON & METAL CO.
552 Penobscot Building, Detroit, Mich.

FOR SALE

GAS ENGINES

1—Fairbanks-Morse, Hor. 60-hp., Type H, equipped for Gas or Gasoline operation; also equipment for Kerosene operation.

1—Foos Hor. 50-hp. Gas Engine.

SOUTHERN ACID & SULPHUR CO.
1303 Boatmen's Bank Bldg., St. Louis, Mo.

GUARANTEED MOTORS

220-440 v., 60 cy., 3 ph.
1 H.P. G.E. 1800 R.P.M.
200 H.P. G.E. 500 R.P.M.
All sizes between the foregoing.

1000 boilers, engines, pumps, generators and motors always in stock.

WICKES MACHINERY CO.
Jersey City, N. J.

SEARCHLIGHT
SERVICE
SECURES
SATISFACTORY
SITUATIONS

2003

WHAT AND WHERE TO BUY

A Classified Index of Advertisers in this Issue

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Acid Concentration Apparatus
- Buffalo Foundry & Machine Co.
- Chemical Construction Co.
- Duriron Castings Co.
- International Glass Co., The
- Kalbperry Corp., The
- Oakland Copper & Brass Works.
- Pratt Eng. & Machine Co.
- Thermal Syndicate, Ltd., The

Acid Distillation Apparatus
- Buffalo Foundry & Machine Co.
- Pratt Eng. & Mach. Co.
- Thermal Syndicate, Ltd., The
- Valley Iron Works (Wmspt., Pa.)

Acid Eggs, Cast Iron
- Bethlehem Fdry. & Mach. Co.
- Buffalo Foundry & Mach. Co.
- Devine Co., J. P.
- Elyria Enameled Products Co.
- Glass Coating Co.
- Lummus, The Walter E., Co.
- Pratt Eng. & Mach. Co.
- Stearns-Roger Mfg. Co.
- Stuart & Peterson Co.
- U. S. Cast Iron Pipe & Fdry. Co.
- Valley Iron Works (Wmspt., Pa.)

Acid Eggs, Stoneware, Acid Proof
- Knight, Maurice A.
- U. S. Stoneware Co.

Acid Resisting Glass Enameled Apparatus
- *See Enameled Apparatus, Acid Resisting*

Acid Ware
- *See Enameled Ware, Glassware, Porcelain, Silica and Stoneware*

Aeroplane Dope
- Hercules Powder Co.

Agitating Machinery
- Buffalo Foundry & Machine Co.
- New England Tank & Tower Co.
- Nickle, Frank H.
- Werner & Pfleiderer Co., Inc.

Agitator Tanks, Wood
- Atlantic Tank & Barrel Co.
- New England Tank & Tower Co.
- Pacific Tank & Pipe Co.
- Stearns Lumber Co., A. T., The

Agitators
- Blaw-Knox Co.
- Dorr Co., The
- General Filtration Co.
- General Machine Co.
- Johnson, John Co.
- New England Tank & Tower Co.
- U. S. Stoneware Co.
- Werner & Pfleiderer Co., Inc.

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- Ingersoll-Rand Company
- Taylor Instrument Companies
- Worthington Pump & Mach. Corp

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- Atmospheric Conditioning Corp.
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- Spray Engineering Co.
- Sturtevant, B. F. Co.

Air Lift Pumping System
- Ingersoll-Rand Company
- Schutte & Koerting Co.
- Worthington Pump & Mach. Corp.

Air Separators
- *See Separators, Air*

Air Washers
- American Blower Co.
- Atmospheric Conditioning Corp.
- Carrier Engineering Corporation
- Sturtevant, B F., Co.

Alkalies
- Solvay Process Co.

Alloys
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Alloys, Special
- American Magnesium Corp.
- Metal & Thermit Corp.
- Norton Laboratories

Amines
- Newport Chemical Wks.

Aluminum
- Aluminum Company of America
- Electric Smelt. & Alum. Co.

Ammeters
- Weston Elec. Instrument Co.

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- Lummus, The Waller E. Co.

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- Bausch & Lomb Optical Co.
- Braun Corporation, The
- Braun-Knecht-Heimann Co.
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- Central Scientific Co.
- Daigger, A., & Co.
- Denver Fire Clay Co.
- Eimer & Amend
- Harger Co., F. D.
- Hoskins Mfg. Co.
- Kauffman-Lattimer Co.
- Laboratory Apparatus Co. (Pittsburgh).
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- Palo Company
- Sargent, E. H., & Co.
- Scientific Materials Co.
- Scranton Glass Inst. Co., Inc.
- Thomas Co., Arthur H.
- Welch Manufacturing Co., M. W.

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- Harger Co., F. D.
- Uehling Instrument Co
- Williams Apparatus Company.

Anodes, Graphite
- Acheson Graphite Co.

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- Insley Manufacturing Co.

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- Permutit Co.

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- Permutit Co.

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- Green Engineering Co.

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- Beaumont, R. H. Co.
- Blaw-Knox Co.
- Gifford-Wood Co.
- Jeffrey Mfg Co.
- Guarantee Construction Co.

Assayers
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Autoclaves
- Blaw-Knox Co.
- Buffalo Foundry & Mach. Co.
- Devine, J. P., Co.
- Ott, Geo. F., Co.
- Stokes, F. J., Machine Co.
- Valley Iron Works (Wmspt., Pa.)
- Warren Foundry & Machine Co.

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- Pratt Eng. & Mach. Co.

Automatic Skip Hoist Controllers
- Cutler-Hammer Mfg. Co.

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- Ainsworth, Wm., & Sons
- American Kron Scale Co.
- Bausch & Lomb Optical Co.
- Braun Corporation, The
- Braun-Knecht-Heimann Co.
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- Eimer & Amend
- Gaertner, Wm., & Co.
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- Palo Company
- Schaar & Co.
- Scientific Materials Co.
- Welch Manufacturing Co., W. M.

Ball Mills
- *See Mills, Ball, Pebble, Tube*

Barometric Condensers
- Buffalo Foundry & Machine Co.
- Ingersoll-Rand Company

Barrels, Steel, Bilge, Agitator and Open Head
- Detroit Range Boiler and Steel Barrel Co.

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- Newark Wire Cloth Co.

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- Speer Carbon Co.
- Stackpole Carbon Co.

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- Hercules Powder Co.

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- Barber-Green Company
- Bartlett & Snow, The C. O., Co.
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- Caldwell, H. W., & Son Co.
- Gifford-Wood Co.
- Goodrich Rubber Co., B. F.
- Jeffrey Mfg. Co.
- Link-Belt Company
- Webster Mfg. Co., The

Belting, Silent Chain
- Morse Chain Co.

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- Beaumont Co., R. H.
- Brown Hoisting Machinery Co.

Bleaching Powder
- Arnold Hoffman & Co., Inc.
- Electro-Bleaching Gas Co.

Blowers, Fan or Positive Pressure
- Abbé Engineering Co.
- American Blower Co.
- Beach-Russ Company
- Buffalo Forge Co.
- Connersville Blower Co.
- Nash Engineering Co.
- Roots, P. H. & F. M., Co
- Sturtevant, B. F., Co.

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- Connersville Blower Co.
- Nash Engineering Co.
- Roots, P. H. & F. M., Co.

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- Gas Engineering Co

Boiler Coverings
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- Magnesia Association of America

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- Permutit Co.
- Lea Courteney Co.

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- Coatesville Boiler Works

Boilers, Water Tube
- Vogt, Henry, Machine Co.
- Wickes Boiler Co.

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- Abbé Engineering Co.

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- Lefax, Inc.
- McGraw-Hill Book Company
- Scientific American Pub. Co.

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- M. A. Knight
- U. S. Stoneware Co.

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- Armstrong Cork & Insulation Co.
- Carborundum Co.
- Crescent Refractories Co.
- Denver Fire Clay Co.
- Foote Mineral Co.
- Gravert, Wm. Jr., Inc.
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- Carborundum Co.

Brick, Insulating
- Armstrong Cork & Insulation Co.
- Celite Products Co.

Brick, Silica
- Harbison-Walker Refractories Co.

Bronze, Titanium Aluminum
- Titanium Alloy Mfg. Co.,

Brushes, Carbon
- National Carbon Co.
- Speer Carbon Co.
- Stackpole Carbon Co.

Buckets, Clamshell & Drug Line
- Blaw-Knox Co.
- Brown Hoisting Machinery Co.

Bucket Elevators
- Bartlett & Snow, The C. O., Co.
- Beaumont Co., R. H.
- Blaw Knox Co.
- Caldwell, H. W., & Son Co.
- Gifford-Wood Co.
- Jeffrey Mfg. Co.
- Link-Belt Company
- Webster Mfg. Co., The

Builders, Industrial, Analytical
- Austin Co., The

Buildings, Fireproof
- Austin Co., The

Buildings, Standard Factory
- Austin Co., The

Buildings, Steel
- Austin Co., The
- Blaw-Knox Co.

Buildings, Wood
- Austin Co., The

Bunsen Burners
- Detroit Heating & Lighting Co.
- Tirrill Gas Machine Lighting Co.

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- Braun-Knecht-Heimann Co.
- Maxon Premix Burner Co.
- Monarch Mfg. Works
- Rockwell, W. S., Co.
- Schutte & Koerting Co.

Burners, Powdered Coal
- Mine & Smelter Supply Co.
- Pulverized Fuel Equipment Corp.
- Quigley Furnace Spec. Co.

Burners, Sulphur
- Pratt Eng. & Machine Co.
- Schutte & Koerting Co.
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Cabinets, Laboratory
- Schwartz Sectional System

Calcined Sulphate of Soda
- Atlas Power Co.

Calciners
- Christie, L. R.

Calculating Machines
- Monroe Calculating Machine Co.

Calorimeters
- Central Scientific Co.
- Gaertner, Wm., & Co.
- Palo Co.
- Sargent, E. H., & Co.
- Schaeffer & Budenberg Mfg. Co.
- Scientific Materials Co.
- Scranton Glass Inst. Co., Inc.
- Taylor Instrument Companies
- Thomas, Arthur H., Co.
- Union Thermometer Co.

Carbon, Projector
- Speer Carbon Co.
- Stackpole Carbon Co.

Carbons, Battery
- National Carbon Co.

Carbons, Resistance
- National Carbon Co.

Car Wheels
- Fuller-Lehigh Co.

Cars, Industrial
- Easton Car & Construction Co.
- Insley Manufacturing Co.

Cars, Mine and Ore
- Easton Car & Construction Co.
- Insley Manufacturing Co.
- Mine & Smelter Supply Co.

Cars, Tank
- General Amer. Tank Car Corp.
- Petroleum Iron Works Co.

Cascade Basins, Acid Proof
- Duriron Castings Co.
- Thermal Syndicate, Ltd., The

Casseroles
- Guernsey Earthenware Co.
- Herold China & Pottery Co.

Castings, Acid Proof
- Bethlehem Fdry. & Mach. Co.
- Buffalo Fdry. & Mach. Co.
- Duriron Castings Co.
- Garrigue, Wm., & Co.
- Pacific Foundry Co.
- U. S. Cast Iron & Fdry. Co.
- Valley Iron Works (Wmspt., Pa.)

Castings, Bonze & Brass
- Titanium Alloy Mfg. Co., The

Castings, Chemical
- Bethlehem Fdry. & Mach. Co.
- Buffalo Fdry. & Mach. Co.
- Duriron Castings Co.
- Fuller-Lehigh Co.
- Garrigue, Wm., & Co.
- Jacoby, Henry E.
- Pacific Foundry Works Co.
- Phoenix Iron Works Co.
- Pratt Eng. & Mach. Co.
- Sperry, D. R., & Co.
- U. S. Cast Iron Pipe & Fdry. Co.
- Valley Iron Works (Wmspt., Pa.)
- Wheeler Condenser Co.

Castings, Iron
- Buffalo Foundry & Machine Co.
- Cast Iron Pipe Publicity Bureau
- Garrigue, Wm. & Co.
- Glamorgan Pipe & Foundry Co.

Castings, Monel Metal
- Supplee-Biddle Hardware Co.

Castings, Pure Copper
- Titanium Alloy Mfg. Co.,

Castings, Silicon
- Carborundum Co.

Castings, Special and Chilled
Buffalo Foundry & Machine Co.
Fuller-Lehigh Co.
Phoenix Iron Works Co.
U. S. Cast Iron Pipe & Fdry. Co.

Caustic Pots
See Pots, Cast Iron, Acid Proof

Caustic Soda and Chlorine Liquid
Arnold Hoffman & Co., Inc.
Bleach Process Co.
Electro-Bleaching Gas. Co.
Electro Chem. Supply & Eng. Co.

Caustic Soda and Chlorine
Electrolytic Cells for Making
Arnold Hoffman & Co., Inc.
Bleach Process Co.
Electrolytic Engineering Corp.
Electron Chemical Co.
Warner Chemical Co.

Causticizing Apparatus
Buffalo Foundry & Machine Co.
Dorr Co., The
Glamorgan Pipe & Foundry Co.
Scott, Ernest, & Co.
Zaremba Co.

Celluloid Solvents
Hercules Powder Co.

Cement, Acid Proof
Anti-Hydro Waterproofing Co.
Chemical Construction Co.

Cement Cloth
Ludlow-Saylor Wire Co., The

Cement, Furnace
Carborundum Co.
Dixon, Jos., Crucible Co.
Gravert, Wm. J., Inc.
Quigley Furnace Specialties Co.

Centrifugals
Fletcher Works
Lea-Courtenay Co.
Sharples Specialty Co.
Tolhurst Machine Works
U. S. & Cuban Allied Eng. Wks. Co.

Chain Doors
Codd, E. J., Co.

Chains, Automobile Engine
Morse Chain Co.

Chains, Block
Morse, Chain Co.

Chains, Drive
Morse Chain Co.

Chains, Power Transmission
Morse Chain Co.

Chains, Silent, Rocker-Joint
Morse Chain Co.

Chains, Sprocket Wheel
Morse Chain Co.

Chemical Apparatus
See Acid Eggs, Castings, Chemical, Distilling Machinery and Apparatus, Drying Machinery and Apparatus, Enameled Apparatus, Evaporators, Filter Presses, Glassware, Separators, Centrifugal, Stoneware, etc.

Chemical Cabinets
Schwartz Sectional System

Chemical Castings
Warren Foundry & Machine Co.

Chemical Engines
Amer. La France Fire Eng. Co.

Chemical Equipment, Ultra Violet Ray
R. U. V. Company, The

Chemical Stoneware
See Stoneware, Chemical

Chemicals
Arnold Hoffman & Co., Inc.
Atlas Powder Co.
Baker, J. T., Chem. Co.
Barrett Co., The
Braun Corporation, The
Braun-Knecht-Heimann Co.
Central Scientific Co.
Cooper Co., Chas. A.
Daigger, A., & Co.
Denver Fire Clay Co.
Eimer & Amend
General Chemical Co.
Hercules Powder Co.
Hooker Electrochemical Co.
Kauffman-Lattimer Co., The
Laboratory Apparatus Co. (Pittsburgh)
Lenz Apparatus Co.
Merck & Co.
Newport Chemical Wks., Inc.
Roessler & Hasslacher Chemical Co., The
Sargent, E. H., & Co.
Schaar & Co.
Scientific Materials Co.
Welch, W. M., Mfg. Co.
Wilkins-Anderson Co.
Will Corporation, The

Chemists, Manufacturing
Atlas Powder Co.
Baker, J. T., Chem. Co
Cooper Co., Chas. A.
Hooker Electrochemical Co.
Merck & Co.
Newport Chemical Works, Inc.
Roessler & Hasslacher Chemical Co., The

Chemists and Chemical Engineers
See Professional Directory,
167, 168, 169

Chlorine, Liquid
See Caustic Soda and Chlorine

Chrome, Ore
Lavino, E. J., & Co.

Classifiers
Colorado Iron Works Co.
Dorr Co., The
Worthington Pump & Mach. Corp.

Clay, Fire
Denver Fire Clay Co.

Clay Goods
See Brick and Clay, also Porcelain Ware, also Stoneware, Chemical

Clay Goods, Porous
Cleansing Soda Solvay Process Co.
Maddock & Sons, John

Cleaning Soda
Solvay Process Co.

Cloth, Carborundum & Aloxite
Carborundum Co.

Coal Handing Machinery
Gifford-Wood Co.
Guarantee Construction Co.

Coal and Materials Storage Systems
Guarantee Construction Co.

Coal Tar Pitch
Barrett Co., The

Coal Tar Products
Newport Chemical Works, Inc.

Cocks, Cast Iron, Acid Proof
See Valves and Cocks, Cast Iron, Acid Proof

Cocks, Stoneware, Acid Proof
See Valves and Cocks, Stoneware, Acid Proof

Coils, Copper
Badger, E. B., & Sons Co.
Whitlock Coil Pipe Co.

Coil Pipe
Whitlock Coil Pipe Co.

Coils and Worms, Stoneware
See Stoneware, Chemical

Collectors, Dust
Buffalo Foundry & Machine Co.
Dust Recovering & Conveying Co.
Northern Blower Co., The

Color Testing Equipment, Ulta Violet Ray
R. U. V. Company The

Combustion Boats
Engelhard, Chas.

Combustion Equipment
American Engineering Co.

Compressors, Air or Gas
Beach Russ Co.
Chicago Pneumatic Tool Co
Connersville Blower Co.
Crowell Mfg. Co.
General Electric Co.
Nash Engineering Co.
Roots, P. H. & F. M., Co.

Concrete, Acid-Resisting
Anti-Hydro Waterproofing Co.

Concrete Construction
Austin Co., The
Blaw-Knox Co.

Condenser, Barometric, Surface or Jet
Buffalo Fdry. & Mach. Co.
Connersville Blower Co.
Devine Co., J. P.
Lummus, The Walter E., Co.
Stokes, F. J., Machine Co.
Wheeler Condenser Co.
Worthington Pump & Mach. Corp.

Condensers
International Oxygen Co.
Scranton Glass Inst. Co., Inc.

Controllers, Temperature
Powers Regulator Co., The

Converters, Rotary
General Electric Co.

Conveying Machinery
See Machinery, Elevating and Conveying

Conveyors, Ash, Steam Jet
Green Engineering Co.

Conveyor Belts
Goodrich Rubber Co., B. F.

Conveyors, Pneumatic
Dust Recovering & Conveying Co.

Conveyors, Portable
Barber-Greene Company
Jeffrey Mfg. Co.
Portable Machinery Co.
Stephans-Adamson Mfg. Co.

Coppersmithing
Badger, E. B., & Sons Co.
Lummus, The Walter E., Co.
Ott, George F., Co

Copper Tubes, Seamless Draw
Wheeler Condenser & Engrg. Co.

Cranes
Brown Hoisting Machinery Co.

Cranes, Locomotive
Brown Hoisting Mach. Co.,
Link-Belt Company

Crucibles, Industrial
Acheson Graphite Co.
Bartley, Jonathan, Crucible Co.
Dixon, Jos., Crucible Co.
Duriron Castings Co.
Mine & Smelter Supply Co.
Thermal Syndicate, Ltd., The

Crucibles, Graphite
Acheson Graphite Co.
Bartley, Jonathan, Crucible Co.
Dixon, Jos., Crucible Co.

Crucibles, Laboratory
American Platinum Works
Buffalo Dental Mfg. Co.
Denver Fire Clay Co.
Guernsey Earthenware Co.
Scientific Materials Co.

Crushers, Grinders and Pulverizers
See Machinery, Crushing, Grinding and Pulverizing

Crushers, Grdrs., Pulv'z'rs, Lab.
See Machinery, Crushing, Grinding and Pulverizing Laboratory

Crystallizing Dishes & Pans, Stoneware
See Stoneware, Chemical

Crystallizing Pans, Cast Iron
Buffalo Foundry & Machine Co.
Devine Co., J. P.
Pfaudler Company

Cupels
Denver Fire Clay Co.
Dixon, Jos., Crucible Co.

Curb Boxes, Meter
Cast Iron Pipe Publicity Bureau

Cyanide
Atlas Powder Co.

Cyanide Machinery
See Machinery, Cyanide

Derrick
Insley Manufacturing Co.

Diaphragms, Acid Proof
General Filtration Co.

Die Castings (Bronze)
Titanium Alloy Mfg. Co., Inc.

Diffusion Batteries
Blair, Campbell & McLean, Inc.
Swenson Evaporator Co.

Digesters
Blaw-Knox Co.
Elyria Enameled Products Co.
Glass Coating Co.
Manitowoc Engineering Works
Stuart & Peterson Co.
Swenson Evaporator Co.

Disintegrators
Jeffrey Mfg. Co.
Stedman's Fdry. & Mach. Works.

Dissolving Machines
Lummus, The Walter E., Co.

Distilling Machy. and Apparatus
Badger, E. B., & Sons Co.
Blair, Campbell & McLean, Inc.
Buffalo Foundry & Machine Co.
Detroit Heating & Lighting Co.
Devine Co., J. P.
Duriron Castings Co.
Eimer & Amend
Elyria Enameled Products Co.
Glass Coating Co.
Isbell-Porter Co.
Koven, L. O., & Bro.
Lummus, The W. E., Co.
Mott, J. L., Iron Works
Oakland Copper & Brass Works.
Ott, George F., Co.
Pfaudler Co., The
Scientific Materials Co.
Scott, Ernest, & Co.
Stevens-Aylsworth Co.
Stokes, F. J., Machine Co
Stuart & Peterson Co.
Swenson Evaporator Co.
Thomas Co., Arthur H.
Zaremba Co.

Doors, Chain Screen
Codd, E. J., Co.

Drives, Silent Chain
Morse Chain Co.

Drop Forge Fittings
Vogt, Henry, Machine Co.

Drums, Steel
Detroit Range Boiler and Steel Barrel Co.
Devine, J. P., Co.

Dry Blast Plants
Carrier Engineering Corporation

Dry Cell Filler
Acheson Graphite Co.

Dryers, Centrifugal
Elmore, G. H.
Fletcher Works
Sharples Specialty Co.
Tolhurst Mach. Works
U. S. & Cuban Allied Eng'g Wks. Co.

Dryers, Vacuum
Buffalo Foundry & Machine Co.
Devine, J. P., Co.
Jacoby, Henry E.
Scott, Ernest, & Co.
Sowers Mfg. Co.
Stokes, F. J., Machine Co.

Drying Machinery and Apparatus
American Blower Co.
American Process Co.
Bartlett & Snow, The C. O., Co.
Buckeye Dryer Co., The
Buffalo Forge Co.
Buffalo Foundry & Machine Co.
Christie, L. R.
Devine Co., J. P.
Farrar & Trefts, Inc.
Fleisher, W. L., & Co., Inc.
Fuller-Lehigh Co.
Gordon Dryer Corp.
Kalbperry Corporation
Koven, L. O., & Bro.
Manitowoc Engineering Works
Philadelphia Drying Machry. Co.
Philadelphia Textile Mach. Co.
Ruggles-Coles Eng. Co.
Scott, Ernest, & Co.
Stearns-Roger Mfg. Co.
Stokes, F. J., Machine Co.
Swenson Evaporator Co.
Vulcan Iron Works

Dust Collecting Systems & Engineers
Dust Recovering & Conveying Co.
Kalbperry Corporation
Northern Blower Co.
Paxson, J. W., Co.
Pratt Eng. & Machine Co.
Raymond Bros. Imp. Pul. Co.

Dynamos, Electroplating
See Electroplating Dynamos, Supplies

Dynamos and Motors
Bogue, C. J., Elec. Co.
Connecticut Dynamo Co.
General Electric Co.
Jantz & Leist Elec. Co.
Westinghouse Electric & Mfg. Co.

Electric Cranes
See Cranes

Electric Furnaces
See Furnaces, Electric

Electric Furnaces, Laboratory
See Furnaces, Elec. Lab'y

Electrical Testing Sets
American Transformer Co.
Thordarson Electric Mfg. Co.

Electrodes, Carbon
Acheson Graphite Co.
National Carbon Co.
Republic Carbon Co.
Speer Carbon Co.
Stackpole Carbon Co.

Electrodes, Graphite
Acheson Graphite Co.

Electrolyte
Atlas Powder Co.

Electrolytic Cells
Bleach Process Co.
Electro-Chemical Supply & Engineering Co.
Electrolytic Eng. Corp.
Electrolytic Oxy-Hydro. Lab., Inc.
Electron Chemical Co.
International Oxygen Co.
Warner Chemical Co.

Electrolytic Oxygen and Hydrogen Generators
Electrolytic Oxy-Hydro. Lab., Inc.
International Oxygen Co.

Electroplating Salts
Roessler & Hasslacher Chem. Co.

Electroplating Dynamos; Supplies
Bogue, C. J., Elect. Co.
Connecticut Dynamo Co.
Eager Electric Co.
Jantz & Leist Elect. Co.

Elevating and Conveying Machinery
See Machinery, Conveying and Elevating

Elevators, Steam Hydraulic
Craig Ridway & Sons Co.

Enameled Apparatus, Acid Resisting
Elyria Enameled Products Co.
Glass Coating Co.
Mott, J. L., Iron Works
Pfaudler Co., The
Stearns-Roger Mfg. Co.
Stuart & Peterson Co.

Engineers, Chemical, Consulting, Analytical, Industrial
Also see Professional Directory,
167, 168, 169
Austin Co., The
Bleach Process Co.
Dust Recovering & Convey. Co.
Fleisher, W. L., & Co.
General Engineering Co.
General Machine Co., Inc.
Kalbperry Corp. The
Little Arthur D., Inc.
Pulverized Fuel Equipment Corp.
Pratt Eng. & Machine Co.
Uehling Instrument Co.
Williams Apparatus Company

Engineers, Combustion
American Engineering Co.
Combustion Engineering Co.
Garrigue, Wm., & Co.
Improved Equipment Co.
Pulverized Fuel Equipment Corp.
Uehling Instrument Co.

Engineers and Contractors
Guarantee Construction Co.

Engineers, Construction
Austin Co., The
Chemical Construction Co.
Green, Samuel M., Co.
Thompson-Starrett Co.

Engineers, Furnace
Hagan, Geo. J., Co.
Rockwell, W. S., Co.
Russell Engineering Company

Engines, Steam and Hauling
Vulcan Iron Works

Evaporating Dishes
The Acid Proof Clay Products Co.
Guernsey Earthenware Co.
Knight, Maurice A.
Mine & Smelter Supply Co.
Robinson Clay Product Co.
Thermal Syndicate, Ltd., The
U. S. Stoneware Co.

Evaporators
Badger, E. B., & Sons Co.
Blair, Campbell & McLean, Inc.
Blaw-Knox Co.
Buffalo Fdry. & Mach. Co.
Devine, J. P., Co.
International Oxygen Co.
Jacoby, Henry E.
Kestner Evaporator Co.
Koven, L. O., & Bro.
Lummus, The W. E., Co.
Oakland Copper & Brass Works
Ott, Geo. F., Co.
Pfaudler Co., The
Pratt Eng. & Machine Co.
Scott, Ernest, & Co.
Sowers Manufacturing Co.
Sperry, D. R., & Sons
Stokes, F. J., Machine Co.
Swenson Evaporator Co.
Werner & Pfleiderer Co., Inc.
Wheeler Condenser & Engrg. Co.
Zaremba Co.

Exhausters
Glamorgan Pipe & Foundry Co.
Roots, P. H. & F. M., Co.
Schutte & Koerting Co.

Extractors
Badger, E. B., & Sons Co.
Blair, Campbell & McLean, Inc.
Blaw-Knox Co.
Buffalo Foundry & Machine Co.
Devine, J. P., Co.
Koven, L. O., & Bro.
Lummus, The Walter E., Co.
Ott, Geo. F., Co.
Scranton Glass Inst. Co., Inc.

Extractors, Centrifugal
Fletcher Works
Sharples Specialty Co.
Tolhurst Machine Works
U. S. & Cuban Allied Eng'g Wks. Co.

Fans
Buffalo Forge Co.
General Electric Co.
Philadelphia Drying Machry. Co.
Philadelphia Textile Mach. Co.
Pratt Eng. & Machine Co.
Raymond Bros. Impact Pulv. Co.
Schutte & Koerting Co.
Stearns-Roger Mfg. Co.
Sturtevant, B. F., Co.

Fans, Stoneware, Acid Proof
General Ceramics Co.
Knight, Maurice A.
U. S. Stoneware Co.

Faucets, Stoneware, Acid Proof
See Stoneware, Chemical

Feeders
American Pulverizing Co.
Bartlett & Snow, The C. O., Co.
Jeffrey Mfg. Co.
Webster Mfg. Co., The

Felt
Widney Co., The

Felts (Paper Makers)
Albany Felt Co.
Huyck, F. C., & Sons
Ludlow-Saylor Wire Co., The

Fences, Chain Link
Anchor Post Iron Works

Fences, Iron and Wire
Anchor Post Iron Works

Fences, Unclimbable, Factory
Anchor Post Iron Works

Ferro-Alloys
Continuous Reaction Co., The
Ferro-Alloy Co., The
Lavino, E. J., & Co.
Leavitt, C. W., & Co.
Metal & Thermit Corp.
Standard Alloys Co.
Titanium Alloy Mfg. Co.

Ferro-carbon—Titanium
See Titanium

Ferro-Chrome
Lavino, E. J., & Co.

Ferro-Manganese
Lavino, E. J., & Co.

Ferro-Molybdenum
Lavino, E. J., & Co.

Ferro-Silicon
Lavino, E. J., & Co.

Ferro-Tungsten
Lavino, E. J., & Co.

Filing Cabinets
Schwartz Sectional System

Filing Systems
Lefax, Inc.

Filter Cloth
Albany Felt Co.
Huyck, F. C. & Sons

Filter Cloth (Metallic)
Ludlow-Saylor Wire Co.
Multi-Metal Co., Inc.
Newark Wire Cloth Co.
Supplee-Biddle Hardware Co.
Trumpbour-Whitehead Brass & Copper Co., Inc.
Tyler, The W. S., Co.
United Filters Corp.

Filter Paper
Angel, H. Reeve, & Co.
Eimer & Amend
Laboratory Supply Co., The
Scientific Materials Co.

Filter, Porous Porcelain
Herold China & Pottery Co.

Filter Presses
Abbé Engineering Co.
American Continuous Filter Co.
Colorado Iron Works Co.
Industrial Filtration Corporation
Jacoby, Henry E.
Johnson, John, Co.
Kelly Filter Press Co.
Koven, L. O., & Bro.
Lungwitz, E. E.
Oliver Continuous Filter Co.
Patterson Fdry. & Mach. Co.
Perrin, Wm. F., & Co.
Shriver, T., & Co.
Sperry, D. R., & Co.
Sweetland Filter Press Co.
United Filters Corp.

Filtering Media
Celite Products Co.
General Filtration Co.

Filters
Blaw-Knox Co.
Permutit Co.

Filters, Air
Dust Recovering & Conveying Co.

Filters, Dust
Dust Recovering & Conveying Co.

Filters, Laboratory
Perrin, Wm. R., & Co.

Filters, Oil
Permutit Co.

Filters, Rotary Continuous
American Continuous Filter Co.
Chalmers & Williams
Colorado Iron Works Co.
General Filtration Co.
Glamorgan Pipe & Foundry Co.
Industrial Filtration Corp.
Kelly Filter Press Co.
Oliver Continuous Filter Co.
Sweetland Filter Press Co.
United Filters Corp.

Filters, Suction, Stoneware, Acid Proof
General Ceramics Co.
Knight, Maurice A.

Filters, Vacuum
General Filtration Co.
Stevens-Aylsworth Co.

Filters, Water
Hungerford & Terry, Inc.
Permutit Co.

Fire Brick and Clay
See Brick and Clay, Fire

Firebrick, Cement
Gravert, Wm. J., Inc.

Firebrick, Special Shapes
Gravert, Wm. J., Inc.

Fire Extinguishers
American-La France Fire Engine Co.

Fire Sand Carborundum
Carborundum Co.

Floor Grating
Irving Iron Works

Flooring
Irving Iron Works

Flooring, Metallic
Irving Iron Works

Flooring, Non-Slipping
Irving Iron Works

Floors & Pits, Acid Resisting
Anti-Hydro Waterproofing Co.
Barrett Co., The

Flotation Apparatus
Braun Corporation, The
Braun-Knecht-Heimann Co.
Colorado Iron Works
Mine & Smelter Supply Co.
Roots, P. H. & F. M., Co.

Fluorspar
Lavino, E. J., & Co.

Fluxes
Shawinigan Electro Metals Co.

Forms, Business
Lefax, Inc.

Foundry Supplies & Equipment
Electric Smelting & Alum. Co.
Paxson Co., J. W.

Fuel Economizer
Magnesia Assn. of America

Fulminate of Mercury
Atlas Powder Co.

Furnace Cement
See Cement, Furnace

Furnace Doors, Chain
Codd, E. J., Co.

Furnace Engineers
See Engineers, Furnace

Furnace Facings and Linings
Acheson Graphite Co.
Celite Products Co.
Crescent Refractories Co.
Dixon, Jos., Crucible Co.
Gravert, Wm. J., Inc.
Quigley Furnace Specialties Co.

Furnace Hoists
Brown Hoisting Machinery Co.

Furnace Insulation
Celite Products Co.

Furnace Manufactures
Hamilton & Hansell, Inc.

Furnace Supplies
Gravert, Wm. J., Inc.

Furnaces, Assay
Braun Corporation, The
Braun-Knecht-Heimann Co.
Denver Fire Clay Co.

Furnaces, Brass and Aluminum Melting
Detroit Electric Furnace Co.
Electric Furnace Co., The
Pittsburgh Furnace Co.
U. S. Smelting Furnace Co.

Furnaces, Caustic Pot
Nickle, Frank H.

Furnaces, Chloridizing and Sulphating
Wedge Mechanical Furnace Co.

Furnaces, Cupola, Foundry
Worthington Pump & Mach. Corp.

Furnaces, Electric
The Detroit Electric Furnace Co.
Electric Furnace Co.
Hamilton & Hansell
Leavitt, C. W., & Co.
Pittsburgh Furnace Co.

Furnaces, Electric, Laboratory
Brown Instrument Co., The
Central Scientific Co.
Electric Htg. Apparatus Co.
Engelhard, Chas.
Hoskins Mfg. Co.
Mine & Smelter Supply Co.
Scientific Materials Co.

Furnaces, Heat Treating
Brown Instrument Co., The
Denver Fire Clay Co.
Electric Furnace Co., The
Electric Htg. Apparatus Co.
Engelhard, Chas.
Hagan, Geo. J., Co.
Hoskins Mfg. Co.
Mine & Smelter Supply Co.
Rockwell, W. S., Co.
Russell Engineering Co.
Wedge Mechanical Furnace Co.

Furnaces, Melting:
Oil, Gas or Powdered Coal
Hagan, Geo. J., Co.
Mine & Smelter Supply Co.
Rockwell, W. S., Co.
Russell Engineering Company
U. S. Smelting Furnace Co.

Furnaces, Muffle
Electric Heating Appar. Co.
Hoskins Mfg. Co.
Improved Equipment Co.
Mine & Smelter Supply Co.
Russell Engineering Company
Wedge Mechanical Furnace Co.

Furnaces, Roasting and Smelting
Allis-Chalmers Mfg. Co.
Colorado Iron Works Co.
General Chemical Co., The
Mine & Smelter Supply Co.
Pacific Foundry Co.
Russell Engineering Company
Wedge Mechanical Furnace Co.
Worthington Pump & Mach. Corp.

Furnaces, Rotary and Tilting
U. S. Smelting Furnace Co.

Furnaces, Sulphur
General Chemical Co., The
Kalbperry Corp.
Pacific Foundry Co.
Pratt Eng. & Machine Co.
Wedge Mechanical Furnace Co.

Furnaces, Water Cooled Appliances for High-Temperature
Blaw-Knox Co.

Fused Silica
Thermal Syndicate, Ltd., The

Gas, High Pressure
International Oxygen Co.

Gas Holders
Gas Engineering Co.

Gas Machines
Detroit Heating & Lighting Co.
Tirrill Gas Machine Lighting Co.

Gas Masks
Mine Safety Appliances Co.

Gas Producers
Chapman Eng. Co.
Flinn & Dreffein Co.
Gas Engineering Co.
Hagan, Geo. J., Co.
Improved Equipment Co.
Morgan Const. Co.
Smith Gas Engineering Co., The
Steere Engineering Co.
Wellman-Seaver-Morgan Co.

Gas Pumps and Exhausters
See Pumps, Gas, Liquid or Vacuum

Gas Purifiers
Gas Engineering Co.

Gas Scrubbers and Washers
Bartlett Hayward Co.
Buffalo Forge Co.
Gas Engineering Co.

Gaskets
Sarco Company, Inc.
Widney Co., The

Gates, Iron & Wire
Anchor Post Iron Works

Gauges, Recording, Indicating, Draft Pressure
Bristol Co., The
Brown Instrument Co.
Pneumercator Co., Inc.
Schaeffer & Budenburg Mfg. Co.
Taylor Instrument Companies
Thwing Instrument Co.
Uehling Instrument Co.
Union Thermometer Co.

Gears
Caldwell, H. W., & Son Co.

Gears, Compensating
Morse Chain Co.

Gears, Silent
General Electric Co.
Morse Chain Co.

Gears, Spring
Morse Chain Co.

Generators
See Dynamos and Motors

Generators (Oxygen and Hydrogen)
Electrolytic Oxy-Hydrogen Lab., Inc.

Glass Blowing
Central Scientific Co.
Denver Fire Clay Co.
International Glass Co.
Kauffman-Lattimer Co., The
Laboratory Supply Co.
Lenz Apparatus Co.
Scientific Materials Co.
Scientific Utilities Co.

Glassware, Chemical
Flasks, Breakers, Crystallizing Dishes, Hydrometer Jars, Petri Dishes, etc.
Central Scientific Co.
Durand-Koering Glass Co., Inc.
Eimer & Amend
Fry Glass Co., H. C.
Griebel Instrument Co.
International Glass Co., The
Kauffman-Lattimer Co., The
Scientific Materials Co.
Scientific Utilities Co.
Will Corp'n, The

Glaubers Salt
Atlas Powder Co.

Graphite
Acheson Graphite Co.

Gratings
Combustion Engineering Co.
Irving Iron Works

Grating, Subway
Irving Iron Works

Grinding Wheels
Carborundum Co.

Grinders
See Machinery, Crushing, Grinding and Pulverizing

Guy, Stiff Leg, Steel
Insley Manufacturing Co.

Hardness Testers
Holz, Herman A.
Widney Co., The

Heat Insulation
Celite Products Co.
Magnesia Assn. of America

Heaters, Feed Water
Atmospheric Conditioning Corp.

Heaters, Noiseless
Schutte & Koerting Co.

Heating Apparatus and Systems
American Blower Co.
Atmospheric Conditioning Corp.
Buffalo Forge Co.
Fleisher & Co., W. L.
Parks-Cramer Co.
Powers Regulator Co., The
Ruggles-Coles Eng. Co.
Sarco Co., Inc.
Sturtevant B. F. Co.

Heating Regulators
Powers Regulator Co., The

Hoists
Brown Hoisting Machinery Co.
Chicago Pneumatic Tool Co.

Hoppers, Standard cast iron for materials
Green Engineering Co.

Hose, all kinds
Goodrich Rubber Co., B. F.

Hydraulic Machinery
Hydraulic Press Mfg. Co., The

Hydraulic Presses
Hydraulic Press Mfg. Co., The
Philadelphia Drying Mach'ry Co.

Hydrogen Generating Apparatus
Electrolytic Oxy-Hydrogen Lab., Inc.
Improved Equipment Co.
International Oxygen Co.

Hydrogen Plants
Electrolytic Oxy-Hydrogen Lab., Inc.
Improved Equipment Co.

Hydrometers
Brown Instrument Co., The
Griebel Instrument Co.
Scientific Utilities Co.
Scranton Glass Inst. Co., Inc.
Taylor Instrument Co.
Union Thermometer Co.

Instruments, Electrical and Testing
Bristol Co., The
Brown Instrument Co.
Central Scientific Co.
Eimer & Amend
General Electric Co.
Hoskins Mfg. Co., The
Pneumercator Co., Inc.
Precision Ther. & Inst. Co.
Pyroletric Instrument Co.
Schaeffer & Budenburg Mfg. Co.
Shore Instrument Co.
Stupakoff Laboratories
Thwing Instrument Co.
Uehling Instrument Co.
Welch, W. M., Manufacturing Co.
Westinghouse Elec. & Mfg. Co.
Widney Co., The

Instruments (Electrical Measuring)
Weston Electrical Instrument Co.

Insulating Material, Electric
Redmanol Chemical Products Co.

Insulating Material, Heat
Armstrong Cork & Insulation Co.
Celite Products Co.
Magnesia Association of America

Intermediates
Marden, Orth & Hastings Corp.
Newport Chemical Works, Inc.

Jackets (Paper Makers)
Albany Felt Co.
Huyck, F. C., & Sons

Jigs
Worthington Pump & Mch. Corp.

Kettles, Cast Iron, Acid Proof
Bethlehem Fdry. & Mach. Co.
Buffalo Fdry. & Mach. Co.
Devine, J. P., Co
Duriron Castings Co.
Pacific Foundry Co.
Sowers Manufacturing Co.
Stevens-Aylsworth Company
U. S. Cast Iron Pipe & Fdry. Co.
Valley Iron Wks., Wmspt., Pa.

Kettles, Enameled, Acid Proof
Elyria Enameled Products Co.
Glass Coating Co.
Mott, J. L., Iron Works
Pfaudler Co., The
Stuart & Peterson Co.

Kettles, Steam Jacketed
Blaw-Knox Co.
Buffalo Fdry. & Machine Co.
Day & Co., J. H.
Detroit Heating & Lighting Co.
Devine Co., J. P.
Duriron Castings Co.
Elyria Enameled Products Co.
Glass Coating Co.
Koven, L. O., & Bro.
Lummus, The Walter E., Co.
Mott, J. L., Iron Works
Ott, George F., Co.
Pfaudler Company, The
Pratt Eng. & Machine Co.
Stevens-Aylsworth Co.
Stuart & Peterson Co.
Werner & Pfleiderer Co., Inc.

Kettles, Stoneware, Acid Proof
See Stoneware, Chemical

Kiln, Lime
Crescent Refractories Co.
Glamorgan Pipe & Foundry Co.
Improved Equipment Co.
Maxon Premix Burner Co.
Vulcan Iron Works

Kiln, Rotary & Nodulizing
American Process Co.
Ruggles-Coles Eng. Co.
Vulcan Iron Works

Laboratory Apparatus and Supplies
Bausch & Lomb Optical Co.
Braun Corporation, The
Braun-Knecht-Heimann Co.
Buffalo Dental Mfg. Co.
Central Scientific Co.
Charlotte Chemical Lab. The, Inc.
Daigger, A., & Co.
Denver Fire Clay Co., The
Detroit Heating & Lighting Co.
Eimer & Amend
Gaertner, Wm., & Co.
Griebel Instrument Co.
Guernsey Earthenware Co.
Hoskins Mfg. Co.
International Glass Co.
Kauffman-Lattimer Co., The
Laboratory Apparatus Co. (Pittsburgh)
Lenz Apparatus Co.
Leonard, Peterson & Co., Inc.
Multi-Metal Co.
Palo Co.
Pyroletric Instrument Co.
Sargent, E. H., & Co.
Schaar & Co.
Scientific Materials Co.
Scientific Utilities Co.
Thomas Co., Arthur H.
Tirrill Gas Machine Lighting Co.
Union Thermometer Co.
Welch, W. M., Mfg. Co.
Werner & Pfleiderer Co., Inc.
Wilkins-Anderson Co.
Will Corp'n, The

Lacquers
Hercules Powder Co.

Lamps, Arc & Incandescent
General Electric Co.

Leather Cloth Solutions
Hercules Powder Co.

Leather, Hydraulic
Schieren Co., Chas. A.

Lifting Magnets
Cutler-Hammer Mfg. Co.

Lifts, Air Jet
Bethlehem Fdry. & Mach. Co.
Lummus, The Walter E., Co.
Monarch Mfg. Works, Inc.

Loaders, Bucket
Barber-Greene Company

Loaders, Pneumatic
Dust Recovering & Conveying Co

Loaders, Wagon and Truck
Gifford-Wood Co.

Locomotives, Gasoline
Fate, J. D., Co.

Locomotives, Industrial
Fate, J. D., Co.
General Electric Co.
Jeffrey Mfg. Co.
Vulcan Iron Works

Machinery, Agitating
Buffalo Foundry & Machine Co.
Day & Co., J. H.
Dorr Co., The
Gedge-Gray Co., The
Johnson, John, Co.
New England Tank & Tower Co.
Stokes, F. J., Machine Co.
Werner & Pfleiderer Co., Inc.

Machinery, Automatic Weighing
American Kron Scale Co.
Garrigue, Wm., & Co.
Pneumercator Co., The, Inc.
Schaffer Eng. & Equipment Co.
Werner & Pfleiderer Co., Inc.

Machinery, Bleach Powder
Bleach Process Co.

Machinery, Classifying
Dorr Co., The

Machinery, Coal Grinding
Aero Pulverizer Co.
American Pulverizer Co.
Jeffrey Mfg. Co.
Mine & Smelter Supply Co.
Pratt Eng. & Machine Co.
Raymond Bros. Impt. Pulv. Co.
Williams Patent Crusher & Pulv Co.

Machinery, Conveying & Elevating
Bartlett & Snow, The C. O., Co
Beaumont, R. H., Co.
Caldwell, H. W., & Son Co.
Dust Recovering & Conveying Co
Gifford-Wood Co.
Jeffrey Mfg. Co.
Link-Belt Company
Portable Machinery Co.
Robins Conveying Belt Co.
Stephens-Adamson Mfg. Co.
Valley Iron Works, Wmspt., Pa.
Webster Mfg. Co., The
Wellman-Seaver-Morgan Co.

Machinery, Crushing, Grinding and Pulverizing
Abbé Eng'g Co.
Aero Pulverizer Co.
Allis-Chalmers Mfg. Co.
American Pulverizer Co.
Bartlett & Snow, The C. O., Co.
Bradley Pulverizer Co.
Buchanan, C. G. & Co.
Chalmers & Williams
Colorado Iron Works Co.
Day & Co., J. H.
Fuller-Lehigh Co.
Jeffrey Mfg. Co.
K-B Pulverizer Co.
Kent Mill Co.
Mead & Company
Mine & Smelter Supply Co.
Patterson Fdry. & Mach. Co.
Pratt Eng. & Machine Co.
Raymond Bros. Imp. Pulv. Co.
Stedman's Foundry & Mach. Wks
Sturtevant Mill Co.
Vulcan Iron Works
Williams Patent Crusher & Pulverizer Co.
Worthington Pump & Mchy. Corp

Machinery, Crushing, Grinding & Pulverizing Laboratory
Abbé Eng'g Co.
Bacon, E. C.
Braun Corporation, The
Braun-Knecht-Heimann Co
Central Scientific Co.
Chalmers & Williams
Jeffrey Mfg. Co.
Scientific Materials Co.
Sturtevant Mill Co.
Thomas Co., Arthur H.

Machinery, Cyanide
Allis-Chalmers Mfg. Co.
Colorado Iron Works Co.
Dorr Co., The
Worthington Pump & Mchy. Corp

Machinery, Dyeing
Philadelphia Drying Machry. Co

Machinery, Metallurgical and Mining
Abbé Eng'g Co.
Aero Pulverizer Co.
Allis-Chalmers Mfg. Co.
American Continuous Filter Co.
American Process Co.
Chalmers & Williams
Colonial Supply Co.
Colorado Iron Works Co.
Denver Engr'g Works Co., The
Dorr Co., The
Dwight & Lloyd Sintering Co.
Fuller-Lehigh Co.
General Chemical Co., The
Huff Electrostatic Separator Co.
Kelly Filter Press Co.
Kent Mill Co.
Lungwitz, E. E.
Mine & Smelter Supply Co., The
Pacific Foundry Co.
Raymond Bros. Imp. Pulv. Co.
Ruggles-Coles Eng. Co.
Stearns-Roger Mfg. Co.
Sturtevant Mill Co.
Sweetland Filter Press Co.
Tyler, The W. S., Co.
United Filters Corp.
Vulcan Iron Works
Wedge Mechanical Furnace Co.
Worthington Pump & Mchy. Corp.

Machinery, Mixing and Kneading
Abbé Eng'g Co.
Buffalo Fdry. & Machy. Co.
Crossley Machine Co.
Day & Co., J. H.
Gedge-Gray Co., The
Mead & Company
New England Tank & Tower Co.
Patterson Fdry. & Mach. Co.
Pratt Eng. & Machine Co.
Sowers Manufacturing Co.
Stokes, F. J., Machine Co.

Machinery, Ore and Coal Handling
Barber-Greene Company
Bartlett & Snow, The C. O., Co.
Brown Hoisting Machinery Co.
Gifford-Wood Co.
Jeffrey Mfg. Co.
Link-Belt Company
Stephens-Adamson Mfg. Co.

Machinery, Ore Concentrating
Allis-Chalmers Mfg. Co.
Chalmers & Williams
Colorado Iron Works
Denver Engrig. Works Co., The
Dorr Co., The
Kent Mill Co.
Ruggles-Coles Eng. Co.
Mine and Smelter Supply Co.
Worthington Pump & Mchy. Corp.

Machinery, Paper Making, Experimental
Noble & Wood Machine Co.

Machinery, Pipe Bending
American Pipe Bend. Mach. Co.

Machinery, Refrigerating
Vogt, Henry, Machine Co.
York Manufacturing Co.

Machinery, Screening
Allis-Chalmers Mfg. Co.
Bartlett & Snow, The C. O., Co.
Chalmers & Williams
Gifford-Wood Co.
Jeffrey Mfg. Co.
Link-Belt Company
Stephens-Adamson Mfg. Co.
Tyler, The W. S., Co.
Webster Mfg. Co., The
Worthington Pump & Mchy. Corp.

Machinery, Soap
Gedge-Gray Co., The

Machinery, Special
Buffalo Fdry. & Machine Co.
Day & Co., J. H.
Denver Engr'g Works Co., The
Phoenix Iron Works Co.
Ruggles-Coles Eng. Co.
Stevens-Aylsworth Co.
Stokes, F. J., Machine Co.
Werner & Pfleiderer Co.

Machinery, Thickening and Dewatering
Denver Engr'g Works Co., The
Dorr Co., The
Werner & Pfleiderer Co.

Machinery Transmission
Caldwell, H. W., & Son Co.
Jeffrey Mfg. Co.
Morse Chain Co.
Stephens-Adamson Mfg. Co.
Webster Mfg. Co., The

Machinery, Turbine
De Laval Steam Turbine Co.

Machinery, Weighing
American Kron Scale Co.
Garrigue, Wm. & Co.
Pneumercator Co., The, Inc.
Schaffer Eng. & Equipment Co.
Simmons, John, Co.
Sturtevant Mill Co.
Werner & Pfleiderer Co.

Magnesite
Foote Mineral Co.
Harbison-Walker Refractories Co.

Magnesium Metal
American Magnesium Corp.
Leavitt, C. W., & Co.
Norton Laboratories

Magnesium Ribbon
Daigger, A., & Co.

Magnetic Clutches
Cutler-Hammer Mfg. Co.

Magnetic Pulleys
Cutler-Hammer Mfg. Co.
Dings Magnetic Separator Co.
Magnetic Mfg. Co.

Magnetic Separators
Buchanan, C. G. Co., Inc.
Dings Magnetic Separator Co.
Magnetic Mfg. Co.

Magnets
Dings Magnetic Separator Co.
Magnetic Mfg. Co.

Manganese Removal Apparatus
Permutit Co.

Material Storage Hoppers (standard cast iron)
Green Engineering Co.

Materials Handling Equipment
Guarantee Construction Co.

Manganese Ore
Lavino, E. J., & Co.

Metallographic Apparatus
Holz, Herman A.
Palo Co.
Scientific Materials Co.

Metallurgical Engineers
See Professional Directory, Pages 165, 166, 167

Metallurgical Processes
Dorr Co., The
Dwight & Lloyd Sintering Co.

Metals and Alloys
Electric Smelting & Alum. Co.
Ferro Alloy Co., The
Lavino, E. J., & Co.
Leavitt, C. W., & Co.
Metal & Thermit Corp.
Metals Disintegrating Co.

Meter Box Covers
Cast Iron Pipe Publicity Bureau

Meters
Foxboro Co., Inc., The

Meters (Electrical Measuring)
Weston Electrical & Instrument Co.

Meters, Flow, Air, Gas, Water
General Electric Co.
Spray Engineering Co.

Microscopes
Bausch & Lomb Optical Co.
Central Scientific Co.
Palo Co.
Scientific Materials Co.
Thomas Co., Arthur H.

Mills, Ball, Pebble and Tube
Abbé Eng'g Co.
Allis-Chalmers Mfg. Co.
Chalmers & Williams
Colorado Iron Works Co.
Denver Eng'r'g Works Co., The
Mead & Company
Patterson Fdry. & Mach. Co.
Stokes, F. J., Machine Co.
Worthington Pump & Mchy. Corp.

Mills, Emery
Sturtevant Mill Co.

Mine Pumps
Lea-Courtney Co.

Mineral Fillers
Elite Products Co.

Minerals and Ores
American Magnesium Corp.
American Rutile Co.
Continuous Reaction Co., The
Foote Mineral Co.
Lavino, E. J., & Co.
Leavitt, C. W., & Co.
Shawinigan Electro-Metals Co.
Stork, Chas. T. & Co.
Vanadium Alloys Steel Co.

Mixed Acid
Atlas Powder Co.

Mixers, Acidulating
Pratt Eng. & Mach. Co

Mixers, Batch
Gedge-Gray Co., The
Pratt Eng. & Mach. Co.
Werner & Pfleiderer Co.

Molybdenum Ore
Foote Mineral Co.
S. W. Shattuck Chemical Co., The

Monel Metal
Multi-Metal Co., Inc.
Supplee-Biddle Hdwre. Co.
Trumpbour-Whitehead Brass & Copper Co.

Montejus
See Acid Eggs, Cast Iron, also Stoneware

Motors, Buffing & Polishing
Eager Electric Co.

Motors, Electric
General Electric Co.
Westinghouse Electric Mfg. Co.

Motor Speed Regulators
Cutler-Hammer Mfg. Co.

Motor Starters
Cutler-Hammer Mfg. Co.

Muffles
Denver Fire Clay Co.
Russell Engineering Company

Muriatic Acid
Atlas Powder Co.

Nickel, Sheet, Rod, Wire, Etc.
Tfompbour-Whitehead Brass and Copper Co., Inc.

Nitrate of Ammonia
Atlas Powder Co.

Nitrate of Soda
Atlas Powder Co.

Nitric Acid
Atlas Powder Co.

Nitro Compounds
Newport Chemical Works, Inc.

Nozzles, Spray
American Blower Co.
Buffalo Forge Co.
Carrier Engineering Corp
Duriron Castings Co.
Eureka Machine Co.
Fleisher & Co., W. L., Inc.
Monarch Mfg. Works, Inc.
Schutte & Koerting Co.
Spray Engineering Co.
Star Brass Works, The

Nozzles & Jets, Stoneware
See Stoneware, Chemical

Oil & Grease Extraction Equipment
Bartlett & Snow, The C. O., Co.

Oleum 20% to 80% SO_3
Atlas Powder Co.

Ore Bedding and Reclaiming Systems
Robins Conveying Belt Co.
Stephens-Adamson Mfg. Co.

Ores
See Minerals and Ores

Ovens, Laboratory
Central Scientific Co.
Thermo-Electric Instrument Co.

Oxygen or Hydrogen Generating Equipment
Electrolytic Oxy-Hydrogen Lab., Inc.

Packing
Goodrich Rubber Co., B. F.

Paint, Pigment, Graphite
Acheson Graphite Co.

Paint, Acid Proof and Technical
Barrett Co., The
Toch Bros.

Palau Ware
Braun Corporation, The
Braun-Knecht-Heimann Co.

Pans, Vacuum
Badger, E. B., & Sons Co.
Blair, Campbell & McLean, Inc.
Buffalo Fdry. & Mach. Co.
Detroit Heating & Lighting Co.
Devine, J. P.
Kestner Evaporator Co.
Devine, J. P., Co.
Lummus, The Walter E., Co.
Pfaudler Company, The
Pratt Eng. & Machine Co.
Scott, Ernest, & Co.
Sowers Manufacturing Co.
Stokes, F. J., Machine Co.
Swenson Evaporator Co.
Werner & Pfleiderer Co., Inc.
Wheeler Condenser & Engrg. Co.
Zaremba Co.

Patent Attorneys
See Professional Directory, Pages 167, 168, 169

Pebble Mills
See Mills, Ball, Pebble and Tube

Perforated Metal
Mundt, Chas., & Sons

Pipe, Cast Iron
Cast Iron Pipe Publicity Bureau
Garrigue, Wm., & Co.
Glamorgan Pipe & Foundry Co.
U. S. Cast Iron Pipe & Fdry. Co.

Pipe, Silica Ware
Thermal Syndicate, Ltd., The

Pipe and Boiler Covering
Celite Products Co.
Magnesia Association of America

Pipe & Fittings, Cast Iron, Acid Proof
Duriron Castings Co.
Elyria Enameled Products Co.
Pacific Foundry Co.
Pfaudler Co., The
Stuart and Peterson Co.

Pipe and Fittings, Copper
Badger, E. B., & Sons Co.
Lummus, Walter E., Co., The
Ott, George F., Co.
Whitlock Coil Pipe Co.

Pipe and Fittings, Enameled, Acid Proof
Elyria Enameled Products Co.
Glass Crating Co.
Pfaudler Co., The
Stuart & Peterson Co.

Pipe and Fittings, Lead, Tin or Silver Lined
Badger, E. B. & Sons Co.
Cleveland Brass Mfg. Co.
Lead Lined Iron Pipe Co.
United Lined Tube & Valve Co.

Pipe and Fittings, Stoneware, Acid Proof
The Acid Proof Clay Prod. Co.
General Ceramics Co.
Graham, C., Chem. Pottery Wks.
Knight, Maurice A.
U. S. Stoneware Co.

Pipe Covering, Wood
Michigan Pipe Co.

Pipe and Fittings, Wood
Michigan Pipe Co.
Mine & Smelter Supply Co.
National Tank & Pipe Co.
Pacific Foundry Co.
Pacific Tank & Pipe Co

Pitch, Coal Tar
Barrett Co., The

Platinum Wire, Sheet and Foil; Crucibles, Dishes, Electrodes, Laboratory Ware, all kinds.
American Platinum Works
Baker & Co., Inc.
Bishop, J., & Co., Platinum Wks.
Palo Co.
Scientific Materials Co.
Thomas Co., Arthur H.

Plug Cocks
See Valves and Cocks

Pneumatic Tools
Ingersoll-Rand Company

Pneumatic Conveying Equipment
Guarantee Construction Co.

Pneumercator
Pneumercator Co., The, Inc.

Porcelain Ware
Bausch & Lomb Optical Co.
Braun Corporation, The
Braun-Knecht-Heimann Co.
Central Scientific Co.
Guernsey Earthenware Co.
Herold China & Pottery Co.

Portable Conveyors
Barber-Greene Company
Portable Machinery Co.
Stephens-Adamson Mfg. Co.

Potasium Cloride
Solvay Process Co.

Pots, Cast Iron, Acid Proof
Bethlehem Foundry & Mach. Co.
Buffalo Foundry & Machine Co.
Duriron Castings Co.
Glamorgan Pipe & Foundry Co.
Pratt Eng. & Mach. Co.
U. S. Cast Iron Pipe & Fdry. Co.
Werner & Pfleiderer Co.

Pots, Stoneware, Acid Proof
See Stoneware, Chemical

Powdered Coal Equipment
Aero Pulverizer Co., The
Dust Recovering & Convey. Co.
Mine & Smelter Supply Co.
Pulverized Fuel Equipment Corp.
Raymond Bros. Impact Pul. Co.
Standard Mechanical Equip. Co.

Precipitators, Centrifugal
Fletcher Works

Producers, Gas
Steere Eng. Co.

Pulverizers, Hammer Mill
American Pulverizer Co.
Bartlett & Snow, The C. O., Co.

Pump Controllers
Cutler-Hammer Mfg. Co.
Pneumercator Co., The, Inc.

Pumps, Acid or Acid Gases
Abbé Eng'g Co.
American Well Works
Beach-Russ Co.
Duriron Castings Co.
Elmore, G. H.
Lea Courtney Co.
Lummus, The Walter E., Co.
Nash Engineering Co.
Nassau Valve & Pump Co.
Roots, P. H. & F. M.
Taber Pump Co.
United Lined Tube & Valve Co.
Worthington Pump & Mchy. Corp.

Pumps, Centrifugal
Abbé Eng'g Co.
Chemical Equipment Co.
Duriron Castings Co.
Elmore, G. H.
Glamorgan Pipe Foundry Co.
Ingersoll-Rand Company
Rumsey Pump Co., Ltd.
Schutte & Koerting Co.
Taber Pump Co.
Wheeler Condenser Co.
Worthington Pump & Mchy. Corp

Pumps, Diaphragms
Dorr Co., The
Johnson, John, Co.

Pumps, Gas, Liq. or Vacuum
Abbé Engineering Co.
Beach-Russ Co.
Crowell Mfg. Co.
Buffalo Fdry. & Mach. Co.
Central Scientific Co.
Connersville Blower Co.
Devine, J. P., Co.
Ingersoll-Rand Company
Nash Engineering Co.
Pratt Eng. & Machine Co.
Roots, P. H. & F. M., Co.

Pumps, Hand
Rumsey Pump Co., Ltd.

Pump, Prine
Lea Courtney Co.

Pumps, Rotary, Oil or Water
Abbé Engineering Co.
Connersville Blower Co.
Taber Pump Co.
Rumsey Pump Co., Ltd.

Pumps, Sand
Krogh Pump & Machinery Co.

Pumps, Stoneware, Acid Proof
General Ceramics Co.
Knight, M. A.
U. S. Stoneware Co.

Pumps, Triplex Power
Rumsey Pump Co., Ltd.

Pyrometers
Braun Corporation, The
Braun-Knecht-Heimann Co.
Brown Instrument Co.
Bristol Co., The
Central Scientific Co.
Engelhard, Chas.
Foxboro Co., Inc., The
Hoskins Mfg. Co.
Palo Company
Pyrolectric Instrument Co.
Sargent, E. T., & Co.
Schaeffer & Budenburg Mfg. Co.
Scientific Materials Co.
Shore Instrument Co.
Stupakoff Laboratories
Taylor Instrument Companies
Thomas Co., Arthur H.
Thwing Instrument Co.
Uehling Instrument Co.

Pyrometer Protection Tubes
Carborundum Co.
Engelhard, Chas.
Herold China & Pottery Co.
Stupakoff Laboratories
Thermal Syndicate, Ltd., The

Pyrometer Sheets, Graphite
Acheson Graphite Co.

Pyroscope
Shore Instrument Co.

Pyroxylin Solutions
Hercules Powder Co.

Quartz, Glass
See also Fused Silica
Engelhard, Chas.
Thermal Syndicate, Ltd., The

Railings, Iron
Anchor Post Iron Works

Railways, Industrial & Portable
Easton Car & Construction Co.

Re-Agent Cabinets
Schwartz Sectional System

Recorders, CO₂
Foxboro Co., Inc., The
Harger, F. D., & Co.
Uehling Instrument Co.

Recording Instruments, Pressure, Temperature, Electricity, Motion, Speed, Time
Bristol Co., The
Brown Instrument Co.
Engelhard, Chas.
Holz, Herman A.
Hoskins Mfg. Co.
Precision Therm. & Instr. Co.
Pyrolectric Instrument Co.
Schaeffer & Budenburg Mfg. Co.
Taylor Instrument Co.
Thomas, Arthur H., Co.
Thwing Instrument Co.
Uehling Instrument Co.
Union Thermometer Co.

Refractories
See Brick and Clay, Fire

Refrigerating Machinery
See Machinery, Refrigerating

Regulators, Automatic Humidity
American Blower Co.
Carrier Engineering Corp.

Regulators, Pressure and Temperature
Brown Instrument Co., The
Connersville Blower Co.
Lummus, The Walter E., Co.
Powers Regulator Co.
Sarco Company, Inc.
Steere Eng. Co.
Taylor Instrument Companies

Resiliometer, Testing
Widney Co., The

Resistant Chemical Glassware
Fry Glass Co., H. C.

Respirators
American La France Fire Engine Co.
Multi-Metal Co., Inc.

Retorts
See Acid Distillation Apparatus

Retorts, Graphite
Bartley, Jonathan, Cruc. Co.

Retorts, Vertical
Buffalo Foundry & Machine Co.
Isbell-Porter Co.

Rheostats, Laboratory
Central Scientific Co.

Rods
W. S. Hough, Jr., Co.
Trumpbour, Whitehead Brass & Copper Co., Inc.

Rolls, Crushing
American Pulverizer Co.
Buchanan, C. G., Co., Inc.
Jeffrey Mfg. Co.
Worthington Pump & Mchy. Corp.
Brown Hoisting Machinery Co.

Safety Devices
Amer. La France Fire Eng. Co.
Mine Safety Appliances Co.

Safety Goggles
American La France Fire Engine Co.
Mine Safety Appliances Co.

Sample Cabinets
Schwartz Sectional System

Scales, Conveyor
American Kron Scale Co.
Schaffer Eng. & Equip. Co.

Scales, Weighing
American Kron Scale Co.
Garrigue, Wm., & Co.
Sturtevant Mill Co.
Werner & Pfleiderer Co., Inc.

Scleroscope
Shore Instrument Co.

Screens
Bartlett & Snow, The C. O., Co.
Caldwell, H. W., & Sons Co.
Colorado Iron Works
Kent Mill Co.
Multi-Metal Co.
Mundt, Chas., & Co.
Newark Wire Cloth Co.
Paterson Fdry. & Mach. Co.
Sturtevant Mill Co.
Stephens-Adamson Mfg. Co.

Screens, Chain
Codd, E. J., Co.

Screens or Cloth, Fertilizer
Ludlow-Saylor Wire Co., The

Screens, Mining
Ludlow-Saylor Wire Co., The

Screens, Wire, Brass, Copper, Steel, etc.
Ludlow-Saylor Wire Co., The
Multi-Metal Co., Inc.
Tyler, The W. S., Co.

Screening Machinery
See Machinery, Screening

Second Hand Equipment
See Searchlight Section, pages 170-178
Archer & Baldwin
Consolidated Products Co.
Fargo Engineering Co.
Gluck Bros.
Machinery Utilities Co.
Morse Bros. Mach. & Supply Co.
Peerless Iron & Metal Co.
Perry, Buxton, Doane Co.
Read, Howard W., Co.
Stewart, Paul & Co.
Standard Elec. & Elevator Co.
Technical Products Co.
Youngstown Welding Co.
Zelnicker, Walter A., Supply Co.

Separators, Air
Aero Pulverizer Co.
Pratt Eng. & Machine Co.
Raymond Bros. Imp. Pulv. Co.
Williams Patent Crusher & Pulverizer Co.

Separators, Centrifugal
Fletcher Works
Sharples Specialty Co.
Tolhurst Mach. Works

Separators, Electrostatic
Huff Electrostatic Separator Co.

Separators, Inclined Vibrating Screen
Tyler, The W. S., Co.

Separators, Magnetic
Buchanan, C. G., Co.
Cutler-Hammer Mfg. Co.
Dings-Magnetic Separator Co.
Magnetic Mfg. Co.
Paxon, J. W., Co.

Separators, Steam and Oil
Atmospheric Conditioning Corp.

Sieves, Laboratory
Multi-Metal Co., Inc.
Newark Wire Cloth Co.

Silent Chain
Link-Belt Company

Silicon Metal
Carborundum Co.

Sintering Processes
Dwight & Lloyd Sintering Co.

Soda Ash
Solvay Process Co.

Softeners, Water
Permutit Co.

Solvents
Hercules Powder Co.

Solvent Recovery Apparatus
Lummus, The Walter E., Co.

Specimen Cabinets
Schwartz Sectional System

Spiegeleisen
Lavino, E. J., & Co.

Split Leather Ropes
Hercules Powder Co.

Sprocket Wheels
Caldwell, H. W., & Son Co.
Link-Belt Company

Sprockets
Fuller-Lehigh Co.

Sprockets, Silent Chain
Morse Chain Co.

Sprockets, Spring
Morse Chain Co.

Stack Netting for Locomotives
Standard Mechanical Equip. Co.

Steel, High Speed
Standard Alloys Co.

Steel Plate Construction
Blaw-Knox Co.
Chicago Bridge & Iron Wks.
Coatesville Boiler Works
Sharpsville Boiler Works

Steel Structural
Blaw-Knox Co.
Insley Manufacturing Co.

Sterilizers, Ultra Violet Ray
R. U. V. Company, The

Stills, Chemical
See Distilling Machinery and Apparatus

Stirrers, Acid Proof
Acheson Graphite Co.
Duriron Castings Co.

Stokers
American Engineering Works
Combustion Engineering Co.
Garrigue, Wm., & Co.
Hagan, Geo. J., Co.

Stokers, Mechanical Chain Grate
Green Engineering Co.

Stoneware, Chemical, consisting of *Bottles, Carboy Stoppers, Coils and Worms, Crystallizing Dishes, Chlorine Generators, Decanting Pots, Dippers, Dipping Dishes, Faucets, Funnels, Kettles, Mortars and Pestles, Nozzles and Jets, Pots and Jars, Pitchers, Retorts, Receivers or Woulff Bottles, Sinks, Storage Jars, etc.*
Acid-Proof Clay Products Co.
General Ceramics Co.
Graham Co., Chem. Pot'ry. Wks.
Knight, Maurice A.
U. S. Stoneware Co.
Weeks, A. J.

Stopper Heads
Bartley, Jonathan, Crucible Co.

Subway Grating
Irving Iron Works

Sulphur Burners
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Sulphur, Crude
Texas Gulf Sulphur Co.
Union Sulphur Co., The

Sulphur Removal Apparatus
Permutit Co.

Sulphuric Acid (Brimstone)
Atlas Powder Co.

Sulphuric Acid Plants
Buffalo Foundry & Machine Co.
Chemical Const. Co.
Electro Chem. Sup. & Eng'g Co.
Kalbperry Corp., The

Supplies, Mill and Mine
Colonial Supply Co.
Mine & Smelter Supply Co.

Switchboards
Electro-Chem. Sup. & Eng'g Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Syphons, Acid, Stoneware
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Monarch Mfg. Works, Inc.
U. S. Stoneware Co.

Syphons, Metal
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Tachometers
Brown Instrument Co., The
Foxboro Co.
Schaeffer & Budenburg Mfg. Co.

Tanks, Acid
Coatesville Boiler Works
Sharpsville Boiler Works

Tanks, Cast Iron
Buffalo foundry & Machine Co.
Detroit Range Boiler and Steel Barrel Co.
Garrigue, Wm., & Co.
Koven, L. O., & Bro.
Stevens-Aylsworth Co.

Tanks, Copper
Badger, E. B., & Sons Co.
Detroit Heating & Lighting Co.
Ott, George F., Co.

Tanks, Cyanide
Stearns Lumber Co., A. T., The

Tanks, Enameled, Acid Proof
Elyria Enameled Products Co.
Glass Coating Co.
Pfaudler Co., The
Stuart & Peterson Co.

Tanks, Heating Regulators
Powers Regulator Co., The

Tanks, Lead Lined, Acid Proof
Acme Tank Co.
Blair, Campbell & McLean, Inc.
Chemical Construction Co.
Dunck Tank Works
Eagle Tank Co.
Hauser-Stander Tank Co.
Johnson & Carlson
Oakland Copper & Brass Works
Stearns Lumber Co., A. T., The
New England Tank & Tower Co.
United Lined Tube & Valve Co.
Wendnagle & Co.

Tanks, Oil
Coatesville Boiler Works
Sharpsville Boiler Works

Tanks, Pressure
Sharpsville Boiler Works Co.

Tanks, Steel
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Chicago Bridge & Iron Wks.
Coatesville Boiler Works
Codd, E. J., Company
Detroit Range Boiler and Steel Barrel Co.
Hamburg Boiler Works
Janney-Steinmetz & Co.
Kellogg, The M. W., Co.
Koven, L. O., & Bro.
Manitowoc Engineering Works
Petroleum Iron Works Co.
Phoenix Iron Works Co.
Stevens-Alysworth Co.
Stevens Brothers

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General Ceramics Co.
Graham, C., Chem. Pot'y Works
Knight, Maurice A.
Petroleum Iron Works
U. S. Stoneware Co.

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Janney-Steinmetz Co.

Tanks, Welded
Kellogg, The M. W. Co.

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Atlantic Tank & Barrel Co.
Corcoran, A. J., Inc.
Dunck Tank Works
Eagle Tank Co.
Hauser-Stander Tank Co., The
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Kalamazoo Tank & Silo Co.
Mine & Smelter Supply Co.
National Tank & Pipe Co.
New England Tank & Tower Co.
Pacific Foundry Co.
Pacific Tank & Pipe Co.
Stearns Lumber Co., A. T., The
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Brown Instrument Co., The
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Bausch & Lomb Optical Co.
Bristol Co., The
Brown Instrument Co., The
Central Scientific Co.
Engelhard, Chas.
Foxboro Co.
Gaertner, Wm., & Co.
Griebel Instrument Co.
Lenz Apparatus Co.
Precision Thermometer & Instrument Co.
Pyroletric Instrument Co.
Schaeffer & Budenburg Mfg. Co.
Scientific Utilities Co.
Scranton Glass Inst. Co., Inc.
Taylor Instrument Companies
Thwing Instrument Co.
Union Thermometer Co.

Thermostats
Powers Regulator Co., The
Sarco Company, Inc.

Thickeners (or Dewaterers)
Dorr Company, The
General Engineering Co.

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American Rutile Co.
Titanium Alloy Mfg. Co.

Titanium Ores
Foote Mineral Co.
Titanium Alloy Mfg. Co.

Tongs, Lifting
Lummus, The Walter E., Co.

Tool Steel
Standard Alloys Co.

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Duriron Castings Co.
Kalbperry Corp.
Thermal Syndicate, The, Ltd.

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General Ceramics Co.
Graham, C., Chem. Pot'y Wks.
Knight, Maurice A.
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Insley Manufacturing Co.
New England Tank & Tower Co.

Towers, Transmission
Blaw-Knox Co.

Transformers
Allis-Chalmers Mfg. Co.
American Transformer Co.
General Electric Co.
Thordarson Electric Mfg. Co.
Westinghouse Electric & Mfg. Co.

Transformers, Special & Precipitation Process
American Transformer Co.
Thordarson Electric Mfg. Co.

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Goodrich Rubber Co., B. F.

Transmission, Silent Chain
Morse Chain Co.

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Standard Mechanical Equip. Co.

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Wheeler Condenser Co.

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Wheeler Condenser & Engrg. Co.

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Continuous Reaction Co., The
Vanadium-Alloys Steel Co.

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Ingersoll-Rand Company

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Easton Car & Construction Co.

Ultra Violet Ray Lamps
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Uranium Alloys
Standard Alloys Co.

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Vacuum Filters
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Vacuum Pans
See Pans, Vacuum

Vacuum Pumps
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Jenkins Bros.

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Chemical Equipment Co.
Cleveland Brass Mfg. Co.
Colonial Supply Co.
Duriron Castings Co.
Johnson, John, Co.
Lead Lined Iron Pipe Co.
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Pratt Eng. & Machine Co.
Schutte & Koerting Co.
United Lined Tube & Valve Co.

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Johnson & Carlson
New England Tank & Tower Co.
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Lummus, The Walter E., Co.

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Lummus, The Walter E., Co.

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Widney Co. The

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Solvay Process Co.

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Anti-Hydro Waterproofing Co.
Barrett Co., The

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Permutit Co.

Water Rectification
Permutit Co.

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Hungerford & Terry
Permutit Co.

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Lea Courtney Co.

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National Carbon Co.

Welding Outfits, Arc
General Electric Co.

Welding Thermit Process
Metal & Thermit Corp.

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Newark Wire Cloth Co.
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Trumpbour-Whitehead Brass & Copper Co.
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Rome Wire Co.

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Devine Co., J. P.
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Braun-Knecht-Heimann Co.
Metals Disintegrating Co.

Zinc Dust
Braun Corporation, The
Braun-Knecht-Heimann Co.
Denver Fire Clay Co.
Merrill Co., The

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American Zinc Products Co.

Zinc Sheets
American Zinc Products Co.

Zirconia
Foote Mineral Co.

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Tyler, The W. S., Co.

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Cutler-Hammer Mfg. Co.
Dings-Magnetic Separator Co.
Magnetic Mfg. Co.
Paxon, J. W., Co.

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Fuller-Lehigh Co.

Sprockets, Silent Chain
Morse Chain Co.

Sprockets, Spring
Morse Chain Co.

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Standard Mechanical Equip. Co.

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Standard Alloys Co.

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Blaw-Knox Co.
Chicago Bridge & Iron Wks.
Coatesville Boiler Works
Sharpsville Boiler Works

Steel Structural
Blaw-Knox Co.
Insley Manufacturing Co.

Sterilizers, Ultra Violet Ray
R. U. V. Company, The

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Stirrers, Acid Proof
Acheson Graphite Co.
Duriron Castings Co.

Stokers
American Engineering Works
Combustion Engineering Co.
Garrigue, Wm., & Co.
Hagan, Geo. J., Co.

Stokers, Mechanical Chain Grate
Green Engineering Co.

Stoneware, Chemical, consisting of *Bottles, Carboy Stoppers, Coils and Worms, Crystallizing Dishes, Chlorine Generators, Decanting Pots, Dippers, Dipping Dishes, Faucets, Funnels, Kettles, Mortars and Pestles, Nozzles and Jets, Pots and Jars, Pitchers, Retorts, Receivers or Woulff Bottles, Sinks, Storage Jars, etc.*
Acid-Proof Clay Products Co.
General Ceramics Co.
Graham Co., Chem. Pot'ry. Wks.
Knight, Maurice A.
U. S. Stoneware Co.
Weeks, A. J.

Stopper Heads
Bartley, Jonathan, Crucible Co.

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Sulphur Burners
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Sulphur, Crude
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Union Sulphur Co., The

Sulphur Removal Apparatus
Permutit Co.

Sulphuric Acid (Brimstone)
Atlas Powder Co.

Sulphuric Acid Plants
Buffalo Foundry & Machine Co.
Chemical Const. Co.
Electro Chem. Sup. & Eng'g Co.
Kalbperry Corp., The

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Mine & Smelter Supply Co.

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General Electric Co.
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Tachometers
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Foxboro Co.
Schaeffer & Budenburg Mfg. Co.

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Coatesville Boiler Works
Sharpsville Boiler Works

Tanks, Cast Iron
Buffalo foundry & Machine Co.
Detroit Range Boiler and Steel Barrel Co.
Garrigue, Wm., & Co.
Koven, L. O., & Bro.
Stevens-Aylsworth Co.

Tanks, Copper
Badger, E. B., & Sons Co.
Detroit Heating & Lighting Co.
Ott, George F., Co.

Tanks, Cyanide
Stearns Lumber Co., A. T., The

Tanks, Enameled, Acid Proof
Elyria Enameled Products Co.
Glass Coating Co.
Pfaudler Co., The
Stuart & Peterson Co.

Tanks, Heating Regulators
Powers Regulator Co., The

Tanks, Lead Lined, Acid Proof
Acme Tank Co.
Blair, Campbell & McLean, Inc.
Chemical Construction Co.
Dunck Tank Works
Eagle Tank Co.
Hauser-Stander Tank Co.
Johnson & Carlson
Oakland Copper & Brass Works
Stearns Lumber Co., A. T., The
New England Tank & Tower Co.
United Lined Tube & Valve Co.
Wendnagle & Co.

Tanks, Oil
Coatesville Boiler Works
Sharpsville Boiler Works

Tanks, Pressure
Sharpsville Boiler Works Co.

Tanks, Steel
Blaw-Knox Co.
Chicago Bridge & Iron Wks.
Coatesville Boiler Works
Codd, E. J., Company
Detroit Range Boiler and Steel Barrel Co.
Hamburg Boiler Works
Janney-Steinmetz & Co.
Kellogg, The M. W., Co.
Koven, L. O., & Bro.
Manitowoc Engineering Works
Petroleum Iron Works Co.
Phoenix Iron Works Co.
Stevens-Alysworth Co.
Stevens Brothers

Tanks, Stoneware, Acid Proof
General Ceramics Co.
Graham, C., Chem. Pot'y Works
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Petroleum Iron Works
U. S. Stoneware Co.

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Tanks, Welded
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Atlantic Tank & Barrel Co.
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New England Tank & Tower Co.
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Pacific Tank & Pipe Co.
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Testing Sieves and Testing Sieve Shakers
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Brown Instrument Co., The
Pyrolectric Instrument Co.

Thermometers
Bausch & Lomb Optical Co.
Bristol Co., The
Brown Instrument Co., The
Central Scientific Co.
Engelhard, Chas.
Foxboro Co.
Gaertner, Wm., & Co.
Griebel Instrument Co.
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Precision Thermometer & Instrument Co.
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Scranton Glass Inst. Co., Inc.
Taylor Instrument Companies
Thwing Instrument Co.
Union Thermometer Co.

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Dorr Company, The
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Titanium
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Titanium Alloy Mfg. Co.

Titanium Ores
Foote Mineral Co.
Titanium Alloy Mfg. Co.

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Lummus, The Walter E., Co.

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Thermal Syndicate, The, Ltd.

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General Ceramics Co.
Graham, C., Chem. Pot'y Wks.
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New England Tank & Tower Co.

Towers, Transmission
Blaw-Knox Co.

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Allis-Chalmers Mfg. Co.
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Thordarson Electric Mfg. Co.
Westinghouse Electric & Mfg. Co.

Transformers, Special & Precipitation Process
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Transmission Belts
Goodrich Rubber Co., B. F.

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Morse Chain Co.

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Wheeler Condenser & Engrg. Co.

Tungsten Metal
Lavino, E. J., & Co.
New Jersey Zinc Company, The

Tungsten Ores
American Metal Co., Ltd.
Continuous Reaction Co., The
Vanadium-Alloys Steel Co.

Turbo Blowers
Ingersoll-Rand Company

Turntables, Industrial Railway
Easton Car & Construction Co.

Ultra Violet Ray Lamps
R. U. V. Company, The

Uranium Alloys
Standard Alloys Co.

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Valves and Cocks
International Oxygen Co.
Jenkins Bros.

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Chemical Equipment Co.
Cleveland Brass Mfg. Co.
Colonial Supply Co.
Duriron Castings Co.
Johnson, John, Co.
Lead Lined Iron Pipe Co.
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Pratt Eng. & Machine Co.
Schutte & Koerting Co.
United Lined Tube & Valve Co.

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Eagle Tank Co.
Hauser-Stander Tank Co.
Johnson & Carlson
New England Tank & Tower Co.
Pacific Tank & Pipe Co.
U. S. Wind Engine & Pump Co.

Ventilator or Car Cloth
Ludlow-Saylor Wire Co., The

Viscosimeters
Bausch & Lomb Optical Co.

Voltmeters
Weston Electrical Instrument Co.

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Jeffrey Mfg. Co.
Link-Belt Company
Portable Machinery Co.

Washers, Cast Iron
Lummus, The Walter E., Co.

Washers, Chemical
Lummus, The Walter E., Co.

Washers, Felt
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Washing Soda
Solvay Process Co.

Waterlocks, Pressure for stokers
Green Engineering Co.

Waterproof Cements
Hercules Powder Co.

Waterproofing Compound (Liquid)
Anti-Hydro Waterproofing Co.
Barrett Co., The

Water Filters
Hungerford & Terry, Inc.
Permutit Co.

Water Purifying Apparatus
Permutit Co.

Water Rectification
Permutit Co.

Water Softeners
Hungerford & Terry
Permutit Co.

Water Still
Jewell Polar Co.
Lea Courtney Co.

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Newark Wire Cloth Co.
Supple-Biddle Hardware Co.
Trumpbour-Whitehead Brass & Copper Co.
Tyler, The W. S., Co.

Wires, Electrical
Rome Wire Co.

Wood Distillation *Apparaus for*
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Blair, Campbell & McLean, Inc.
Devine Co., J. P.
Lummus, The W. E., Co.
Manitowoc Engineering Works
Zaremba Co.

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Braun-Knecht-Heimann Co.
Metals Disintegrating Co.

Zinc Dust
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Braun-Knecht-Heimann Co.
Denver Fire Clay Co.
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Zirconia
Foote Mineral Co.

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